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JOURNAL

OF THE

AMERICAN WELDING SOCIETY

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American Welding Society

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The American Welding Society

The American Welding Society is organized to provide united and co-operative action in extending the knowledge of the art of welding and its field of industrial application. The field for further application of welding is enormous, and progress in it is being delayed only by incomplete knowledge and by the confusing and opposing claims of competing interests.

The Society acts as a clearing house for information. Through papers and monthly meetings of local sections of the Society an opportunity is created for the individual manufacturer, engineer, plant superintendent, foreman, operator, etc., to contribute his own knowledge in welding and at the same time receive the benefit of the combined knowledge and experience of all other members of the Society. Special publications in addition to the regular monthly proceedings are issued from time to time giving results of researches, standardization work and other information of value to the members.

CLASSES OF MEMBERSHIP
Extracts From By-Laws

ARTICLE I.

Section 1. Individuals having received the approval of a majority of the Membership Committee shall become members of this Society upon the payment of dues, except in the case of honorary members who shall be elected by unanimous vote of the full Board of Directors.

Section 2. Membership shall be divided into five classes:

Class A. Sustaining members, being individuals or individuals delegated by corporations, firms, partnerships, etc., interested in the science and art of welding, with full rights of membership.

Annual dues $100.00

Class B. Members, being individuals interested in the science and art of welding, with full rights of membership.

Engineers or individuals competent by experience or training to plan or direct welding operations are eligible to this class.

Annual dues $20.00

Class C. Associate members with right to vote but *not* to hold office, except in Sections as may be provided for by the By-Laws of the Sections. Supervising welders, inspectors and skilled operators, with three or more years' practical experience in welding are also eligible to this class.

Annual dues $10.00

Class D. Operating members, who are welders or cutters by occupation, without the right to vote or hold office except in Sections as may be provided for by the By-Laws of the Sections.

Annual dues $5.00

Write to the Secretary for a membership blank.

AMERICAN WELDING SOCIETY

ESTABLISHED 1919

JOURNAL

VOL. 1 FEBRUARY, 1922 NO. 2

CHANGE IN NAME OF PUBLICATION

The Executive Committee of the Society voted to change the name of our Publication to the "Journal of the American Welding Society." The Committee believes this change would broaden the scope of the publication.

Advertising is also included in this issue, as it was impossible to continue monthly publication without increased revenue. The dues from members of which the National Organization retains half (the other half being returned to local sections) is barely sufficient to pay the ordinary expenses of the Society. Moreover, several members of the Board of Directors feel that these advertisements are of interest to our members and add to the value of the Journal.

The decision to include advertising has rendered necessary the delay in getting out the February issue. We will, however, catch up and after the next two issues, have the Journal in the hands of the members at the end of each current month.

Congratulatory letters are coming in daily from members of the Society and various Publications praising the first issue. We are told to "Keep It Up!"

It is going to be hard work to live up to these expectations but as this Journal was undertaken in accordance with the wishes of our Membership, your full cooperation is expected.

NEEDS FOR COOPERATION

In another part of the "Proceedings" under Research Activities there is reproduced a letter which Professor C. A. Adams, as Director of the American Bureau of Welding, sent out to various tank manufacturers. If ever before there existed the need of cooperation among manufacturers that need exists today in the field of welding of pressure vessels. This was displayed very emphatically at a public hearing, held under the auspices of the American Society of Mechanical Engineers on December 5, 1921.

The A. S. M. E. are willing to cooperate with the American Welding Society and its research department, the American Bureau of Welding, in drawing up a code for the welding of unfired pressure vessels which will have the proper requisites of safety without placing unjust restriction on the use of welding in the construction of such vessels. On the other hand, the A. S. M. E. and various State authorities realizing their responsibility to the public in guarding against accidents are going to see to it that a code of this sort will assure a safe product if the specifications given in it are followed in the manufacture and testing of such vessels.

If you are a manufacturer of pressure vessels you will be interested in the plan proposed by Professor Adams. Your comments on it are invited.

ENGLAND PLANS TO ORGANIZE A WELDING SOCIETY

Members of the various sections of the Welding Industry at an Inaugural Meeting, held on the 26th of January at the Holborn Restaurant, adopted the proposal to form a new Welding Society, embracing all systems of welding.

A Strong Committee, with power to add to their number, representing the different interests was elected to draft the Constitution with a view to regis-

tration after same has been approved by a General Meeting, which will be called at an early date.

The name agreed upon is the Institution of Welding Engineers, and all interested in the Welding and Allied Industries will be eligible for membership.

The offices (pro temp.) are at 30, Red Lion Square, London, W. C. I.

SAFETY ENGINEERING AS APPLIED TO OXY-ACETYLENE WELDING AND CUTTING APPARATUS

There is published in this issue a paper on the above subject, delivered by Mr. F. J. Napolitan at a joint meeting of the American Society of Safety Engineers and the Metropolitan Section of the American Welding Society. This paper in conjunction with the one on "Safeguarding the Oxy-Acetylene Process," by Mr. J. I. Banash, as published in the last issue of our Proceedings, really furnishes a symposium on the subject.

WELDING IN SHIP CONSTRUCTION

In the July and August, 1921, News Circular we brought out that seven welded ships were in existence. Since that time three others have come to our attention, one of them being built in this country. The other two were built in Japan and a paper giving a complete description of these latter two ships is printed in this issue. An account of the ship built in this country is given herewith.

In December, 1920, an all-steel constructed boat named the "Sea Hornet" of ten-gauge plates, frames of 1 x 1½ inch angle iron, was launched at the Kyle & Purdy Shipyards at City Island. The "Sea Hornet" was designed as a torpedo boat, for coast defence and is a 600-H.P. motor boat, 58 feet long. Six thousand miles has been covered by the boat up and down the Atlantic Coast in all sort of weather. No leakage signs have shown up to date. There are no seams nor rivets in the hull, which is of all-welded steel construction with special watertight bulkheads and is practically non-sinkable. Its normal capacity is about 800 miles at cruising speed with a maximum speed of about 35 knots.

It is interesting to note in connection with the Japanese ships that Mr. Haramiishi gained enough confidence in welding as the result of an emergency application of welding in the repair of a piston rod. We are quoting Mr. Haramiishi's words of how this came about.

"On one occasion, when we were very busy in the Hikoshima Dockyard, the piston rod of a small 5-cwt. steam hammer, which was the only one in the Smith's shop, fractured in way of the jaw where the tup had to be attached, and became useless. I hurried to the Nagasaki Works to get a new one for it, and at the same time, instructed my staff engineer to repair the cracked one by arc welding by way of a trial, although I was afraid it might not last long. The repair was successfully made, and it was found in practice that the arc welding stood very well against the heavy shocks given by the hammer, and it never failed again. It was used for eight months afterwards, and on examination I could not discover any defects in the welded part at all. (I may say that at that time our welders had very little experience with the process.) The result made me a great believer in arc welding."

WHAT YOU GET OUT OF IT DEPENDS UPON WHAT YOU PUT IN IT

We are quoting below some interesting statements made by Mr. F. A. Anderson, who helped in the formation of the San Francisco Section of the American Welding Society.

"Industry is a necessity in our material well being, and every industrial enterprise uses in one form or another metals of some character. These metals must be joined together in almost every structure or machine that is proposed, and welding in many instances offers the most practical

method for the joining of metals. The object of the American Welding Society is to correct the faults heretofore and at present existing in the art and profession of welding, and to give to industry a perfected science. Everyone interested should be attracted by two principal points: First, the giving in as full a measure as possible all that he can toward this end, and second, to learn from others in order that he may increase his own knowledge. It is the law of life that those who contribute most receive most in return."

THE JOB WELDING SHOP

A number of the job welding shops throughout the country have during the past year or two been forced to adopt more rigid policies in their method of conducting business. President Miller's paper on "Some Problems of the Job Welding Shop" is therefore a timely one.

RESEARCH ACTIVITIES

WORK ON TRAINING OF OPERATORS GIVEN NEW IMPETUS

A meeting of the Committee on the Training of Operators was held in the office of the National Research Council on Thursday, January 19. Under the leadership of the new chairman, Mr. J. C. Wright, of the Federal Board for Vocational Education, a program was laid out for conducting this work on a business-like basis. Mr. Wright has just completed a report on the pulp and paper industry, somewhat similar to that planned by the Committee on Training of Welding Operators. It was agreed at this meeting that the final report should be subdivided as follows:

I. Qualifications for welders, including
   1. Suggestions on the selection of applicants for training.
   2. Suggestions on the testing of welders.
II. Fundamentals of welding.
III. Analysis of welding jobs, including
   1. Oxy-Acetylene welding.
   2. Electric arc welding.
IV. Bibliography of Welding.

It was further agreed that the work of the Committee could be best carried on through three or four day conferences between the Chairman and representatives of the Committee. These conferences have already been started and it is expected that the final report will be well under way before the annual meeting of the Society which occurs during the latter part of April.

WELDED RAIL JOINT COMMITTEE SENDS OUT A QUESTIONNAIRE

The American Electric Railway Association through its Committees on Way Matters initiated the formation of the Committee on Welded Rail Joints for the purpose of having an authoritative investigation made of the various types of welded rail joints now in commercial use. The American Bureau of Welding as the coordinating agency in the general field of welding research and standardization has organized a large Committee comprising over thirty experts on welded rail joints.

Welding is being very widely used in making street railway joints and more or less trouble has been experienced in all types of welded joints from breakage. Little or no scientific data exists as to the correct procedure to be followed in making welds by the various processes. Several of the larger companies are spending many thousands of dollars per year on such joints.

A small Executive Committee has prepared a thorough questionnaire on the four types of welded joints now in use, namely, cast iron, electric seam, resistance and thermit. These were sent out to the members to the Com-

mittee and replies are being forwarded to the Society. From the answers to this questionnaire it is expected that a critical summary will be prepared of our present knowledge based upon all the available experience in this field. A program of research will then be outlined and diferent parts of the program assigned to an appropriate laboratory or in the case of field experiments to one or more appropriate operating companies. These assignments would, of course, cover the men under whom the specific experiments will be conducted.

LETTER SENT TO MANUFACTURERS OF UNFIRED PRESSURE VESSELS

Fusion Welding of Pressure Vessels

Jan. 31, 1922.

Dear Sir:

In March, 1920, the Council of the American Society of Mechanical Engineers requested the American Welding Society to appoint a committee to co-operate with the Boiler Code Committee of the A. S. M. E. in the preparation of that part of its code which deals with the fusion welding of unfired pressure vessels. After a year and a half of work this Committee presented a tentative code to the Boiler Code Committee.

With this assistance the Boiler Code Committee prepared a code covering the points which seemed to them to be pretty well settled, together with an appendix containing questions covering matters on which considerable differences of opinion prevailed. This document was then sent out to interested parties and a hearing was called to which everyone interested was invited. This hearing was held on December 5 and lasted throughout the day.

As is usual on such occasions a great variety of opinions were expressed and many rather broad statements made by those who have had experience in this field, but as a matter of fact the real amount of authentic unbiased experimental evidence contributed was small as compared with the need and importance of the problem.

The fact is that the art of welding has grown up largely from the practical side and even in those cases where the results have been almost wholly successful, the reason why of the success is not always appreciated and the way to guard against the occasional failure is not understood, as the problem is terrifically complex and involves an unusually large number of variables.

The difficulty in all such matters is to get those that are vitally interested commercially, to realize that there is a problem confronting them and it is believed that there is a real problem in this case. There are several aspects that should be considered.

First. The undoubted activity of the state and municipal authorities in connection with all pressure vessels. This is shown by the fact that the state inspectors who have at present nothing to guide them in acceptance of or objection to such vessels, are insistent that some code be provided under which they can work. They have no desire to be unfair or to place undue restrictions on the installation of pressure vessels, but they do feel that some central competent authority should provide rules under which they can work.

Second. The insurance companies are of the same opinion. In a number of cases they have refused to insure pressure vessels until it has been demonstrated that they have been made with proper precautions. It might also be stated that inspectors have taken the same position until proof has been furnished them.

Third. In some cases accidents have resulted from improperly made pressure vessels and these accidents have naturally made the public suspicious of all pressure vessels.

Fourth. There is a great deal of work being done that should never be put in service. As a usual thing it is done by those who have no knowledge of requirements of welding and who through ignorance are causing damage to reputable manufacturers. These things are a source of expense and annoyance to manufacturers who want

to do good work and who do it, and who feel their responsibility.

Needs

1. A set of specifications as to the materials and technique of welding which will assure satisfactory and consistent results, and

2. Specifications for tests which will be conclusive proof that the vessel in question will serve its purpose without failure.

Moreover, these specifications must be such as to convince responsible authorities, not only the Boiler Code Committee itself, but in many cases the state authorities involved, that compliance herewith will result in a safe product.

A very intimate contact with this industry and also with much of the research which has been done in this field, lasting over a number of years, convinces us that the fundamental knowledge necessary to prepare these specifications is not now available. If, therefore, we wish to have a code adopted which will permit of such an intrusion of welding to pressure vessels as will make possible the desired increase in this application of welding and the consequent saving to the nation at large as well as to the manufacturers of such vessels, it is absolutely essential that a comprehensive co-operative research be carried out which will serve as a basis for the specifications for construction and tests, and which will place the industry on a sound foundation.

Inasmuch as the American Bureau of Welding (the research department of the American Welding Society) was organized to provide an unbiased authoritative agency for the conduct of research in this field, and as we have had considerable experience in the organization of such co-operative research work, the following plan of procedure is suggested for your consideration:

Organization

1. That there should be organized a relatively large committee under the American Bureau of Welding and composed of the best experts in the field together with technical representatives of the interested corporations.

2. Under this main committee there should be the ordinary administrative subcommittees such as an executive committee and a ways and means committee. The executive committee should have the necessary authority to conduct most of the routine work since it will be difficult to get attendance at more than very infrequent meetings of the main committee. The ways and means committee, consisting of a few representatives of the largest interested corporations, should have as its chief function the raising of funds for the conduct of the research. These funds should obviously be supplied by the industry itself.

3. Research Committee. This should be a small committee consisting of the best available experts in the country to plan and carry out the actual research work under the general guidance of the main committee.

It is entirely possible that it will be necessary to have several research committees located at different parts of the country where the necessary facilities are available, and dealing with the several phases of the subject.

Program

The program would then be somewhat as follows:

1. The collection of all available knowledge and experience in this particular field.

2. A careful statement of the problem.

3. The laying out of the program.

4. The assignment of the different phases of the problem to appropriate laboratories where the necessary talent and facilities are available. These may be university laboratories, industrial laboratories, or government laboratories, such as the Bureau of Standards, or possibly such commercial laboratories as the Electrical Testing Laboratories of this city.

This is merely intended as a suggestion and covers only some of the more essential features of the organization of this research work.

Finances

The money cost of this work cannot be very well estimated, inasmuch as

some of it will doubtless be conducted by the manufacturers themselves in their own shops and laboratories; but in order to make the work effective, there should be a competent expert who can devote all of his time to the general direction of the research work and it will obviously be necessary to pay for this service. There will also be some office and secretarial expenses unless these can be provided directly by one of the interested corporations.

Comprehensive research work like this cannot be done over night, but will probably require a year or possibly two years. It is all together unlikely that the desired result can be obtained with a cash expenditure of less than $50,000 apart from the actual service contributions of the manufacturers. However, if the manufacturers are in earnest or sincere in their desire to see the weldng of pressure vessels permitted by the responsible authorities, some such plan must be carred out. The first question that must be settled is

1. Will the manufacturers contribute the necessary funds for the conduct of this work. If any large percentage of them participate, the individual contributions will not be large. We are, therefore, writing to get your opinion as to the feasibility of this plan and an expression of your views as to the probability of securing the necessary funds.

It should be borne in mind that the committees of the American Bureau of Welding already include many of the foremost scientific and technical welding experts in the country. The Bureau has also representatives from all the interested scientific organizations as well as the interested government departments. The Bureau is attached to the National Research Council through its Division of Engineering and thus has the backing of this large national scientific organization.

After thinking this matter over, we shall be very glad to receive your comments and particularly an indication of whether or not you will be willing to co-operate financially or otherwise in this undertaking.

Very truly yours

C. A. ADAMS,

Director, American Bureau of Welding.

SECTION NEWS

CHICAGO SECTION ACTIVITIES

One of the most interesting meetings ever held by the Chicago Section, was held on February 3, at the usual meeting place—the auditorium of the Western Society of Engineers, Monadnock Block, Dearborn and Van Buren streets, Chicago, with sixty-five in attendance.

Mr. Edward H. Heidel, of Milwaukee, Boiler Foreman of the Chicago, Milwaukee & St. Paul R. R., presented a most excellent paper on the subject of "Boiler Welding." Mr. Heidel, who has had wide experience in this branch of the welding art, built up the general text of his paper around specific working rules applied under his direction, and in the discussion which followed demonstrated his thorough knowledge of the subject in hand.

Mr. Heidel was followed by Mr. Henry S. Mann, District Manager of the Metal & Thermit Corporation, whose talk on "Thermit Welding" furnished one of the most interesting and informative dissertations on a subject of general interest we have ever had. Mr. Mann's talk was featured by the presentation of two reels of moving pictures illustrating rail welding, and heavy ship repair work by the thermit process, and a considerable number of lantern slides showing the wide range of application of this process.

Following this talk, and under the direction of Mr. Mann, a working demonstration of the thermit process was made by Mr. A. F. Beaulieu, two section of pipe being welded for the benefit of those in attendance.

Mr. Mann's talk was notable, in that he stressed the absolute necessity of having the right man do the right work in all branches of the welding art, condemning the operator as well as the

employer who arranged to perform important welding operations with inadequate welding equipment, or left such work in the hands of an inefficient operator.

It may be well to mention that at this meeting, and in connection with the national membership drive, the needs of the local section as regards membership and finances were laid before the meeting, which resulted in the following pledges for members in this Section—10 Class "A"—38 Class "B"—50 Class "C"—92 Class "D." It is sincerely hoped that these pledges may be redeemed, in order to assure a continuation of such programs as was arranged for this meeting.

The Chicago Section loses a valuable member and director in the resignation of Mr. Don B. McCloud, Secretary-Treasurer of the Gas Products' Association, who is leaving that organization to take up new work with the Norwalk Iron Works, South Norwalk, Conn.

The coming March meeting of the Chicago Section will be held in the auditorium of the Western Society of Engineers, on Friday, March 3. The subject will be "Commercial Applications of the Electric Arc," by Mr. H. E. Dralle, of the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., and will be illustrated by lantern slides especially prepared for this talk. A cordial invitation is extended to all interested in welding to be present at this meeting.

The Chicago Section meets the first Friday in each month at the Western Society of Engineers, and all located within commuting distance of that address should scratch that day off their calendar.

CLEVELAND HOLDS SECOND JOB WELDING SHOP MEETING

The Second Job Welding Shop meeting was held on February 9, at the local Y. M. C. A. Welding School with an attendance of about 40. Most of those present were job shop men and the bulk of them were non-members. Cleveland is always glad to welcome the men who don't belong to our organization as in this way it hopes to interest them and later secure their membership.

Mr. Eberhard, of Eberhard Welding Co., traced the progress of the Job Shop Welders from the ancient days to the condition at present.

The next meeting will be held at the Engineers' Society, Hotel Winton, March 9. Mr. J. F. Lincoln, Vice-President and General Manager of the Lincoln Electric Co., will deliver a paper on carbon-arc welding, with particular references to the merits of the carbon as compared to metallic art, and consideration of the various types of automatic and hand machines.

METROPOLITAN SECTION HOLDS ANOTHER PRACTICAL WELDERS' MEETING

The January meeting, held on the 17th in the Engineering Societies Building, was given over to the practical welders. Considerable good natured arguments arose in several instances as to the relative merits of the gas and electric processes for some particular job. The discussion brought out that in general when a particular process was condemned it was usually caused by a lack of knowledge or improper facilities. However, in some instances one or the other process has inherent advantages. Pressure vessels and cast iron welding received particular attention at this meeting.

The following papers will be read at the meeting of the Metropolitan Section, to be held February 28:

Tank Welding with Metallic and Carbon Arc. By A. L. Price, of Franklin Machine & Steam Boiler Works, Brooklyn, N. Y.

Direct Current Arc Welding Machines. By William Siebenmorgen, Consulting Engineer, New York City.

PRESIDENT MILLER DELIVERS PAPER BEFORE THE NORTHERN NEW YORK SECTION

At the third meeting of the Northern New York Section of the American Welding Society, held on January

26, in the Engineering Building, Union College, S. W. Miller, President of the Society, delivered a lecture, illustrated with lantern slides, on "The Problems of the Job Welding Shop." Mr. Miller is the proprietor of the Rochester Welding Works.

Mr. Miller stated that the three principal problems which the modern welding shop must overcome to be successful are: First, the technical difficulties involved; second, the matter of finances, costs and overhead; third, that of guarantees and the relations with customers. Inasmuch as the work done is almost entirely repairs, the job welder meets with difficulties quite different from those encountered in manufacturing.

Note: Mr. Miller's paper is printed in this issue of the Proceedings.

The next meeting of the Northern New York Section will be held on the 28th at which time a paper will be presented by Mr. F. E. Rogers, of the Davis-Bournonville Company.

PIPE WELDING FEATURED AT THE JANUARY MEETING OF THE PHILADELPHIA SECTION

Three excellent papers on various phases of above subject, illustrated by lantern slides, were presented at this meeting. The first paper by Mr. F. N. Speller, Metallurgical Engineer, National Tube Co., dealt with "Fusion Welding as Applied to Wrot-Pipe Joints." This paper was illustrated by moving pictures, showing the manufacture of hammer weld pipe, which is made in sizes from two feet to eight feet in diameter. The second paper by Mr. E. L. Hopping, Engineer, Mechanical Division, Philadelphia Electric Company, dealt with the "Welding of a 2,200-Foot High Pressure Underground Steam Line in Congested City Streets." Mr. Hopping's paper described in detail the thorough and practical manner in which the Philadelphia Electric Company's Engineers worked out the plans for laying this important steam supply line under some of the busiest streets in Philadelphia and those present were given valuable data developed during the installation of this line. To the foregoing there was added a brief outline by Mr. M. B. Klutz of the methods adopted for executing the field work and reasons why the gas welding was used for certain portions and arc welding for other portions. The title of the third paper was "Production Welding on Steel Tubing and Fittings," delivered by Mr. R. D. Malm, Superintendent Standard Parts Company, Cleveland, Ohio. This paper described the different welding processes utilized in the manufacture of pipe and fittings on a quantity basis and called attention to some of the difficulties which are met and must be overcome.

Future Meetings

Monday, February 20, 1922. Regular meeting.

Monday, March 20, 1922. Regular meeting.

Monday, April 17, 1922. Annual meeting.

Very attractive programs are being arranged for all of these meetings.

JANUARY MEETING—PITTSBURGH SECTION

The January meeting of the Pittsburgh Section was held at the Monongohela House, Tuesday evening, January 31. Mr. J. L. Leeper, of the Westinghouse Air Brake Company who was to present a paper upon the subject of gas welding met with an accident and was unable to carry out his part of the program. The meeting was given over to a practical discussion of different welding jobs. Several pieces of casting were submitted by Mr. H. Meissner, Metallurgist of the Pittsburgh Malleable Iron Co., which provided a subject for interesting discussion.

The February meeting will be held at the Monongohela House on the 24th at which time Mr. H. A. Stewart, Foreman Welder of the National Transit Pump & Machinery Company, Oil City, Pa., will present a paper upon the subject of "Welding of Stellite"—Electric, Gas and Brazing.

PROFESSOR J. C. CLARK, OF STANFORD UNIVERSITY, ELECTED CHAIRMAN, SAN FRANCISCO SECTION, AMERICAN WELDING SOCIETY

The organization meeting of a local section of the American Welding Society was held Friday, January 13, at the Engineers' Club, 57 Post Street. A growing interest in this Society has developed since December 2, when Mr. C. A. McCune, Vice-President of the National Organization, was in San Francisco for the purpose of bringing the message of the Society to those interested in the industrial development of California.

The meeting was preceded by a dinner at the Club and was well attended by representative business men. When the business meeting was called to order thirty-nine persons responded to the roll call, all of them either signing up at the time or expressed their intention of joining this Society.

An outstanding feature of the meeting was an interesting talk by Mr. E. J. McNamee, Engineer of the Morhead Laboratory, who described some very delicate welding which was necessary in the manufacture of the apparatus which this Company produces. He explained that welding was used because it was the only known means which would successfully unite the various metals and that the process must be one capable of producing absolutely accurate results, for not alone was it necessary that each piece be absolutely the same, but that the completed part, including the weld, must subsequently stand the test of being heated to a white heat. The Sectional area of some of these parts was only .003 of a square inch, which shows the delicacy of the operation. Mr. McNamee stated that in this very delicate work it was necessary to employ female help. He also brought out the fact that it required three different kinds of welding on the various parts as the unlike metals would not all respond to one kind of welding.

Mr. K. C. Brackett, of the Air Reduction Company of Emeryville, who at the preliminary meeting was elected temporary chairman, outlined the object of this meeting which was the election of permanent officers and the launching of the San Francisco Section.

Mr. F. A. Anderson, Consulting Engineer, who joined the Society when it was first formed, gave a brief review of the history of the Society and its aims and objects in the industrial world.

The following officers were elected: Professor J. C. Clark, Stanford University, Chairman; Mr. H. L. Wintersgill, Westinghouse Electric & Manufacturing Company, Vice-Chairman; Mr. W. B. Sawyer, Jr., U. S. Steel Products Co., Secretary; Mr. K. C. Brackett, Air Reduction Company (Emeryville), Treasurer.

It is an interesting coincidence that Prof. J. C. Clark was a student under and a friend of many years' standing of Prof. Comfort A. Adams, who was the founder and first President of the American Welding Society. These two men are alike in their fitness for the position and there can be no doubt about the success of the San Francisco Section with a man like Professor Clark to direct its activities.

The meeting was marked with enthusiasm and interest and the date for the next meeting was set for Friday, February 17, at the Engineers' Club. The entire Section formed itself into a committee to go out and carry the message of the Society's opportunity and to try and bring in new members to the next meeting.

EMPLOYMENT SERVICE BULLETIN

To meet the demand of its members, the American Welding Society expects to maintain an Employment Service Bulletin. This service is particularly needed in the present business depression and the coming readjustment. The bulletin will be divided into two sections—POSITIONS VACANT and SERVICES AVAILABLE. No charge will be made either to the available engineer, foreman or welder, or to the organization seeking welding talent. The number of opportunities for employment of which the Society has knowledge does not at present equal the number of men whose services are available. The cooperation of members of the Society, industrial establishments and others needing the services of men trained in the various branches of welding is earnestly desired. The fact that an applicant for a particular position reads the Journal of the American Welding Society shows an honest effort on his part to keep abreast of the latest advancements in his chosen field. The location, necessary qualifications for each position and the approximate salary, if possible, should be stated in each case.

Opportunities.—The Society is glad to learn of desirable opportunities from responsible sources, announcements of which will be published without charge in the bulletin.

Services Available.—Under this heading brief announcements (not more than seventy-five words in length) will be published without charge to members. Anouncements will not be repeated except upon request received after an interval of three months; during this period names and records will remain in the office reference files.

Note.—Copy for publication in the BULLETIN should reach the Society's office not later than the Thirtieth of the month if publication in the following issue is desired. All replies should be addressed to the number indicated in each case and mailed to Society Headquarters.

SERVICES AVAILABLE

A-3. Welder desires position in a machine shop or locomotive shop. Have had four years' experience as electric welder. Can furnish reference. Am member of American Welding Society.

A-4. Experienced welder desires position near Albany. Worked for New York Central Railroad (Rolling Stock Dept.) two years, was in the Army for a year and a half and then went to work for the Staten Island Ship Yards as acetylene welder and stayed with them for a year. I next worked for Cambell Iron Works at Albany, Ludlum Steel Co., Watervliet, N. Y., and last for the N. Y. C. & H. R. R. R. at West Albany Shops (Motive Dept.) till "layed off." Can furnish reference.

Safety Engineering as Applied to Oxy-Acetylene Cutting and Welding Apparatus

By F. J. Napolitan*

THIS discussion can best be introduced by a consideration of the peculiar characteristics of acetylene, about which the entire industry is developed, and its mode of generation. Acetylene is produced from calcium carbide when calcium carbide and water are brought into contact, a simple process clearly exemplified in miner's lamps and flarelights. Do not think, however, that an acetylene generator of welding capacity is a simple device. The modern automatic acetylene generating machine is an elaborate piece of machinery embodying carefully designed devices to make it almost completely fool-proof. When it is considered that the machine of largest capacity is charged with 300 lb. of calcium carbide, capable of generating 1350 cu. ft. of acetylene—and that almost instantaneously, if the control mechanism should fail—it is evident that a most elaborate control mechanism is essential, if a terrific rise in pressure is to be avoided.

That the modern acetylene generator is nevertheless absolutely safe is indicated by the almost negligible number of machines that have proved uncontrollable, and in all such cases it has been found that the operator has removed certain safety devices because they interfered with his leisure, or that some extraordinary and unfair duty was imposed upon the generator.

ACETYLENE AND ITS GENERATION

Acetylene, a hydrocarbon gas like marsh gas, olefin gas or other gaseous compounds of carbon and hydrogen, differs from all of these in one important respect—acetylene is an endothermic compound. In this one characteristic lies the secret of its value to the industry, and yet it is this endothermic property that requires such elaborate care in its generation and handling. When elements combine to form compounds, heat is liberated in the reaction and the compound is said to be exothermic. Practically all complex substances known to chemistry are in this class. Acetylene is one of a very few exceptions. When acetylene is formed heat is absorbed in the reäction and the acetylene compound has a greater heat value than the total heat value of the carbon and hydrogen that it is composed of, actually an excess of 252 B.t.u.'s

*Paper read before joint session of American Society of Safety Engineers and New York Section of American Welding Society, December, 1921, meeting.

per cu. ft. It is conceivable that a compound under these conditions is really supercharged with energy. In the case of acetylene, while we find that at reasonably low pressure the gas is absolutely safe and suitable, yet at pressures variably determined at 2½ and 3 atmospheres, it is readily decomposed by severe detonation. Further than this, a temperature in excess of 1435° F. also produces decomposition.

In view of the fact that acetylene approaches an unstable condition under a pressure of 20 lb. per sq. in., a pressure of 15 lb. per sq. in. is universally accepted as the maximum safe pressure to which acetylene may be generated and at which it may be stored, with an important exception to be indicated later.

The acetylene generator then must be constructed with devices that will positively insure a maximum pressure of 15 lb. per sq. in. The Davis generator will serve as an illustration of the general type. The calcium carbide is stored in the hopper and is controlled by a feeding mechanism actuated by a clock-work motor. Through a diaphragm valve adjusted to operate at 12 lb. per sq. in., the clockwork motor is controlled to start and stop automatically, insuring a continuous flow of acetylene at a constant pressure of 12 lb. per sq. in. until the entire charge of carbide is consumed.

Should the automatic regulating device fail to function, as might happen, a second diaphragm valve, set to operate at 14 lb. per sq. in., throws a cam into the clockwork mechanism, jamming the works. This cam does not return to normal position once it functions, and the operator is immediately aware of a difficulty. It would serve no purpose were he to reset the device without hunting out the trouble, because it would immediately refunction. Should this jam-device fail to operate, a disc blow-off valve, set to operate at 15 lb. pressure per sq. in., would function. This blow-off valve it so attached to the generator that it is operated every time the generator is shut off, insuring effectively against its deteriorating through disuse from corrosion or otherwise. The blow-off valves, of which there are two, discharge into pipes of ample capacity having their outlet through the roof. The purposes in this multiplicity of pressure control devices are, first, to insure positively against the pressure being generated in excess of 15 lb. per sq. in.; second, to maintain a working pressure as near this figure as possible; and third, to control the working pressure so that it never actually reaches the blow-off point, with an attending wastage of gas.

Each of the diaphragm valves is covered with a bonnet vented through the roof so that a leakage of gas past the stuffing boxes will not be discharged into the room. The danger is ever present of an explosion occurring through the ignition of a mixture that might be created in the generating room were a number of such leaks discharging a quantity of gas.

EXPLOSIVE MIXTURES

Probably through its peculiar thermal properties, acetylene forms explosive mixtures that are in greater limits of proportion than any other combustible gas, being exceeded in its low limit of 3 per cent of gas only by ethane which will burn with 2½ per cent of gas, and only equaled in its upper limit by carbon monoxide with 73 per cent of gas. In other words, then, a severe leak of acetylene sufficient to displace 3 per cent of the atmosphere of a room would create a combustible mixture in that room.

These phenomena are considered in the design of the generator. To permit the generator to be recharged with water, a filling device is installed that permits the water to be added through a seal, excluding any air through that source. Air in very small amounts, however, does enter the generating chamber through the carbide filling plug when the latter is removed to permit filling the carbide chamber. Operators are cautioned to observe that before putting the generator into a service line, the pressure should be allowed to build up three times to approximately 5 lb. per sq. in., and the gas purged each time to atmospheric pressure by manually opening one of the blow-off valves. Tests have indicated that the remaining air in the generating chamber is reduced to an insignificont proportion by this expedient.

In a particularly large installation where safety principles are diligently observed even to the sacrifice of production, I designed a simple testing outfit with which the acetylene is tested from each newly charged generator before the generator is permitted to be attached to the service line. The apparatus is an adaptation of the well-known Hemple gas testing assembly, using aerated distilled water for an absorption medium. Acetylene is readily soluble in water, one volume of water dissolving considerably more than an equal volume of acetylene. If the absorption water is sufficiently aerated before being charged into the absorption bulb it will absorb the very last bit of the acetylene and reject any air diluents present in the mixture, which can then be directly read with the measuring burette. If the air proportion exceeds two per cent, the generator is repurged until the gas tests to the proper purity. This work is detailed to an operator who has no preparatory skill in such routine.

The modern acetylene generator is further protected by interference rods, so that in recharging the generator the operator must necessarily follow a certain cycle of operations that will completely avoid the introduction of hazardous elements. For example, the plug closing the carbide filling chamber cannot be removed until an interference device is opened to relieve any pressure remaining in the generator. Another device prevents the sludge water discharge plug from being open until certain valves are operated to vent the generator. Without such a device it is conceivable

that the discharge of the water might create a vacuum in the generator which might cause the shell to collapse or to be severely strained.

There is still another characteristic of actylene generation that must receive consideration in the design of the generator. When

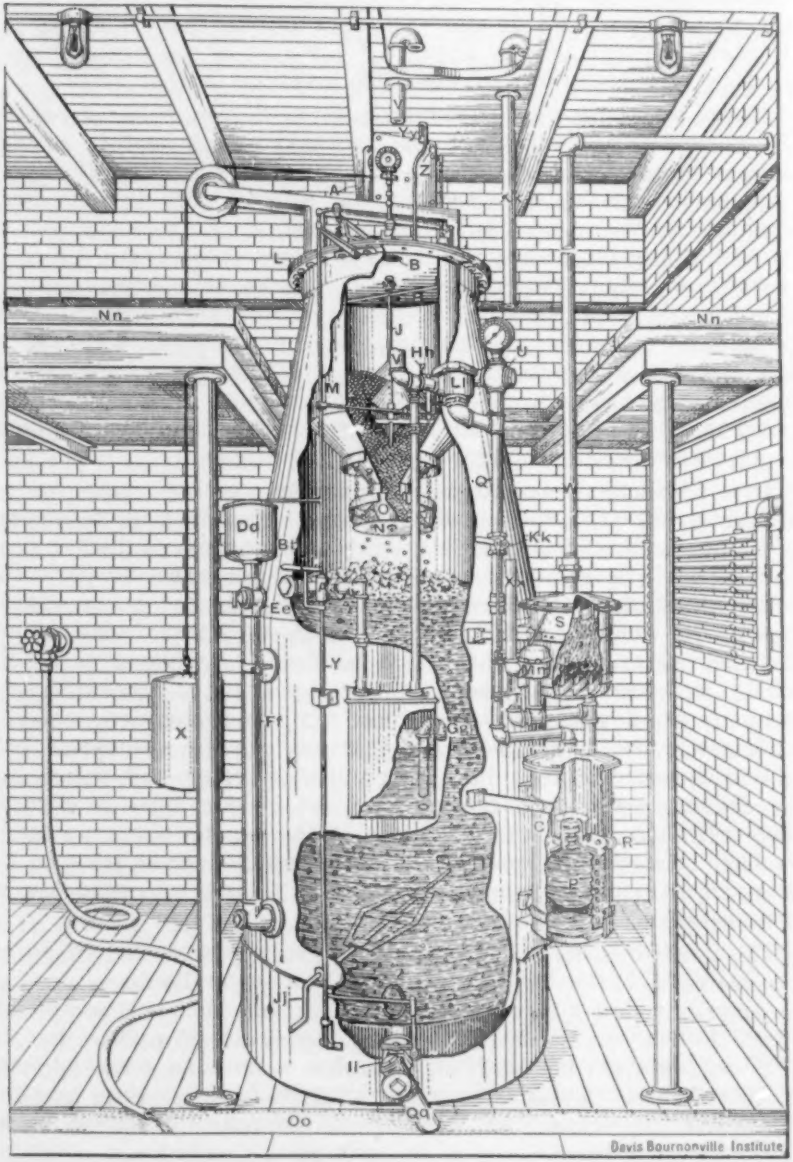


Fig. 1. Acetylene Generator

carbide is added to water the generation of acetylene evolves 900 B.t.u.'s for each pound of carbide used. Were the amount of water insufficient it would conceivably approach a dangerous temperature. A safe rule requires that the water chamber have a capacity of one gallon for each pound of carbide stored in the carbide hopper. Even with this precautionary measure a too-rapid generation of gas might cause a severe overheating of the water. Accordingly, it is the rule that the feeding mechanism should be so adjusted that a full charge of carbide shall not be consumed in less than five hours. Reconciling this against the yield of 4½ to 5 cu. ft. of acetylene from each pound of carbide, it may be determined that a properly designed acetylene generator of say 300 lb. carbide capacity would be charged with 300 gal. of water and have a rated capacity of approximately 300 cu. ft. of acetylene per hour.

The rated capacity of the Davis generator is further maintained by an ingenious device that incorporates a water seal and check valve. The water seal acts as a scrubber and the gas is dried in a drying structure above. The valve is so arranged that it will immediately operate to check a back flow of gas into the generator, and at the same time, acting on a floating principle, will permit only a certain amount of gas to pass through it, closing tight upon an excess flow of gas. Such a device has an added advantage in that should the service line rupture or a fitting be removed while the pressure is maintained in the line, the extraordinary demand created on the generator would cause this valve to close tight and it would not again open until the operator performed a certain cycle of operations that would require the complete shutting down of the generator.

The subject of the design of acetylene pipe lines and the incorporation of certain safety devices is one of extreme importance, but the development is so indeterminate that I think it best to avoid it at this time. Within the coming year I hope to be able to announce as definite a code of rules as control the rest of the process. We shall consider here that having produced acetylene safely in suitable quantities, it may be piped from the generator directly through the shop to supply stations without any more special considerations than are observed in handling any combustible gas, such as ordinary illuminating gas. Particular care should be exercised in producing tight-fitting joints, and the joints should be prepared preferably with litharge and glycerine.

PORTABLE ACETYLENE CYLINDERS AND DISSOLVED ACETYLENE

A great many consumers of acetylene do not find it convenient or economically practicable to generate their own supply of acetylene. Accordingly we are confronted with the problem of storing acetylene in a portable form. Before the extraordinary characteristics of acetylene were known acetylene was compressed in a

free state in cylinders much the same as air. In fact, with its critical pressure of 62 atmospheres and a critical temperature of 84° C., it was possible to liquefy it. But those interested in the process soon found that the destructive explosions of these cylinders indicated that acetylene required a special treatment, as acetylene under a pressure of three atmospheres is unstable and unsafe.

A simple expedient was resorted to and is used to the present day. It was found that acetone, a volatile and combustible liquid, was capable of absorbing 25 times its volume of acetylene at atmosphric pressure. Furthermore, its solubility increases with an increase of pressure. It is believed by some that if the pressure exceeds 30 atmospheres, the mass again becomes unsafe. At 15 atmospheres, or approximately 225 lb. per sq. in., the mixture is absolutely safe, and acetylene cylinders to-day are charged at that pressure.

As acetone expands considerably upon absorbing a quantity of acetylene, it is evident that allowance must be made in the amount of acetone charged into a cylinder. But the free space in a cylinder would be almost as objectionable in that the acetylene occupying the space until the acetone expanded to fill it would be in a free compressed state. Accordingly the entire cylinder is first filled with a porous mixture, in some cases a mixture of charcoal, asbestos, infusorial earth and cement. The mass is poured into the cylinder in the form of a wet paste and the cylinder thoroughly jogged to insure that all crevices are eliminated. When the mass is dry it is found to have approximately 80 per cent of free air space. In other constructions, pads of asbestos wool are used. The cylinder is thoroughly evacuated of air, and acetone added in an amount equivalent to 40 per cent of the total volume of the cylinder, and the acetylene compressed into solution. The amount of acetone is controlled by a ruling of the Interstate Commerce Commission, and its specific gravity must approximate .796. The interstices in the porous mass are so minute that the characteristic of unstability of acetylene at the intermediate pressures is reversed. It is evident that the capacity of the acetone to discharge the dissolved acetylene is a determinable quantity and therefore if the acetylene were drawn from the cylinder too rapidly much of the acetone vapor would be removed with it. This would be objectionable both for economic reasons and for the detrimental effect acetone vapor would have upon the molten metal of welds. Accordingly it is the established rule that acetylene should not be drawn from such cylinders at a rate per hour greater than one-seventh of the total capacity of the cylinder.

With a dissolved acetylene cylinder of ordinary portable size having a rated withdrawal capacity of but 40 cu. ft. of acetylene per hour, and the largest welding apparatus in service requiring 125 cu. ft. of acetylene per hour, some means of coupling several

cylinders together in manifold would be acceptable. In recent years an ingenious device has been developed that permits of this practice which heretofore had been unsafe. This device is a fitting containing a quantity of shot made of soft and low fusion point metal held in place by finely pierced grids. These are placed throughout the manifold assembly in as many different points as the construction permits, dividing the manifold into a multiplicity of sections. Were a high temperature to generate in the vicinity of one of these fixtures the metal pellets would fuse into a solid mass, completely closing off that portion of the assembly that the fitting governed. The combustion then would be confined to a limited volume.

The manufacture of oxygen is closely connected with the oxy-acetylene welding industry. However, the subject is so broad in itself that I must necessarily avoid more than a superficial reference to some of the characteristics of oxygen that are intimately associated with the comfort and safety of the operator. The first process, chronologically speaking, of manufacturing oxygen in commercial quantities was purely chemical, taking advantage of the dissociation of potassium chlorate under the influence of heat. While the oxygen so obtained enabled the infant industry to grow, yet the process was so fraught with danger and uncertainty that it was soon superseded by the liquid air and electrolytic processes, which are the source of oxygen to-day. In the Claude-Linde liquid air process, a mixture of nitrogen and oxygen is liquefied and the liquid so obtained fractionally distilled to separate the oxygen. In the electrolytic process, water is broken up through the medium of the electric current into its constituents, oxygen and hydrogen. The apparatus required for the production of oxygen by the liquid air process is much too elaborate for installation by a consumer in his own factory, but the electrolytic process has been developed to a stage where small units are both practicable and efficient. In the design and manufacture of electric oxygen plants for consumers, safety was paramount in the minds of the designers, and the most elaborate means were observed in insuring against the introduction of any contributory hazards.

PORTABLE OXYGEN CYLINDERS

Liquid air oxygen is supplied to the average consumer compressed in a free state in drawn steel cylinders, the strength of which is under stringent regulations. There is no particular hazard connected with the handling of these cylinders except that associated with any container under an internal pressure of 2000 lb. per sq. in. Before the war, all oxygen cylinders were compressed to 1750 lb. per sq. in. pressure, but the urgent need of cylinders during the war required that the pressure be increased in order to permit of storing more gas in each cylinder. Fortunately the apparatus of the various manufacturers was con-

structed with a sufficient factor of safety so that no radical change was necessary in their designs. All oxygen cylinders are equipped with a fusible plug and bursting disc assembly in order to protect them against a disruptive rise in pressure through intense heat, such as in a fire. Incidentally I have had occasion to examine a number of oxygen and acetylene cylinders that had been in the heart of an intense fire, and while in a number of cases I found that the rise in pressure was too sudden for the safety plugs to accommodate and the cylinders were ruptured, in all such cases the cylinder wall had torn or ripped, but in no case were pieces of cylinder metal projected away from the cylinder. This performance is undoubtedly to be credited to the careful control of the metal entering into their construction.

WITHDRAWAL OF OXYGEN FROM CYLINDER CREATES COLD BY EXPANSION OF GAS

Practically no limit is placed upon the rate at which the gas may be drawn from an oxygen cylinder, except that an extraordinary demand would create intense cold through the expansion of the high-pressure gas into the low-pressure service line. Any water contained in the oxygen would condense and freeze in the regulator and eventually seriously restrict the flow of gas. In general, however, it is found more convenient and an economy of labor to connect a number of oxygen cylinders in manifold, regulating the pressure to the maximum required to insure continuity of flow and pressure through the service line, say 100 lb. per sq. in., and pipe throughout the factory. The manifold, which must evidently be under a pressure of 2000 lb. per sq. in., must be carefully designed with a large factor of safety. Oxygen manifolds are usually made of extra heavy bronze pipe and fittings, with joints of ample length and silver-soldered wherever practice requires. Standard wrought iron pipe is of sufficient strength to convey the gas under ordinary service requirements, although extra heavy pipe is indicated wherever the expense can be borne. Ordinary flammable "dopes," such as shellac or white lead, are to be avoided in making up joints and litharge and glycerine to be recommended instead.

A regulator is required at every service station on both the oxygen and the acetylene supply, in order to reduce the line pressure, and to insure the maintenance of a positive and unfluctuating pressure to the torch. Where the gases are conveyed through pipe lines, the acetylene is under 12 lb. pressure that is maintained by the generator, and the oxygen under 100 lb. or less, so that no special consideration need be given to the strength of these line regulators.

REGULATORS MUST BE DESIGNED FOR PRESSURE

Regulators that are used to reduce the pressure from an oxygen tank pressure of 2000 lb. to a lower working pressure must

be most carefully designed. Oxygen regulators are constructed almost entirely of bronze, with the high pressure fittings of ample strength to afford a high factor of safety.

HIGH-PRESSURE GAUGES

On a by-pass in direct connection with the tank pressure is installed a high-pressure gauge that is usually the product of a responsible gauge manufacturer. The gauge is usually operated through a heavy steel Bourdon tube acting on a train of gears to move the indicator over the dial. The dial usually registers to 3000 lb. pressure and the gauge accurately functions at this maximum pressure. As the highest pressure used in the entire process will never exceed 2000 lb. per sq. in. pressure, it is evident that these gauges are of ample strength. In order, however, to insure against harm should the Bourdon spring rupture, various expedients to relieve the full tank pressure are resorted to by the different manufacturers, through ample openings in the case. One manufacturer, for example, makes a gauge with a solid front integral with the gauge casing. The back is full-flowing, held in place by a relatively weak spring. Were the Bourdon spring to rupture, a slight gas pressure would open the entire back of the gauge, discharging the gas into the atmosphere in a direction away from the operator. Every oxygen gauge bears the caution, "Use No Oil," usually in red paint, and operators are universally aware, by this time, of the danger involved in the presence of oil or any carbonaceous substances in the interior of devices that will convey oxygen. It has been proved that at high pressure oxygen will combine spontaneously with carbonaceous substances, and a violent combustion usually ensues. With propaganda disseminated by every manufacturer associated in the process, pointing to the danger, and with a distinctive caution painted in red on every high-pressure oxygen gauge, yet there persists a few hopeless individuals who will test these high-pressure gauges with an oil testing pump! The initial explosion is not always violent, but it almost invariably creates such intense heat that the conflagration is transmitted to the steel spring and in turn to the gauge body. While the gauge body is usually constructed of brass or bronze, and such copper alloys are not considered combustible, yet the combustion of the steel spring creates sufficient heat and flux action to cause ignition and to maintain combustion of any metallic substances in the zone of reaction. I have examined innumerable gages, however, that evidently contained oil in the interior of the Bourdon spring, and in which the spring had been ignited. While in all cases several inches of the spring had been consumed and the combustion transmitted to the back of the gages, every gage of the floating back type had deflected the reaction toward the back of the gage. In no single case had the reaction been propagated to the face of the gage or in the direction of the operator.

FLAMMABLE RUST-PROOFING COMPOUNDS CAUSE OF TROUBLE

The initial trouble has evidently been almost completely eliminated by two expedients that were suggested by a careful study of the phenomena involved. It was found, first, that some gage manufacturers were using substances of organic origin to rust-proof the interior surfaces of the Bourdon springs. Of course these rust-proofing compounds were changed to others absolutely non-flammable. Strangely, some of the manufacturers were the most flagrant violators of their own most basic cautions to consumers.

It was found that while in isolated instances oxygen would react almost spontaneously with carbonaceous materials, in the majority of cases a determinable heat was required to precipitate the reaction. It was found, further, that when a tank valve was suddenly opened the expansion of the high-pressure oxygen into the regulator fittings of ample capacity, and then subsequently the just as sudden compression of the gas as it entered the Bourdon spring of the gage, would create a considerable rise in temperature at the end of the spring. The temperature, we have proved by experiments, would reach several hundred degrees Fahrenheit. The expedient resorted to here was simply to restrict the opening to the gage with a plug drilled with a minute orifice. Were the tank valve now to be opened suddenly, the flow of oxygen into the gage spring would be considerably impeded, and in passing through the orifice would in reality create a reduction of temperature in the spring. But still, operators are known to have removed this plug because it involved too much trouble to clear it occasionally of accumulated sediment. One operator persisted in the conviction that this small orifice must affect the capacity of the regulator to pass gas, and so he removed the plug.

SELECTING A SEAT TO HOLD BACK THE HIGH-PRESSURE GAS

The observations I have just recorded are again experienced in regulators. I might explain, for the benefit of the uninitiated, that all regulators used in the industry operate on practically the same basic principle. The high-pressure gas is held back by a seat impressed against an outlet nipple of relatively small bore, e.g., $\frac{1}{8}$ in. internal cross section. The seat is directly connected to a flexible diaphragm, through a connecting stirrup. Obviously, an escape of the high-pressure gas past the seat will create a pressure in the service chamber of the regulator, and this pressure will in turn transmit a force to the diaphragm. Eventually the force so generated, acting as it will upon the broad surface of the diaphragm, will overcome the force acting on the seat, and close the latter tight against a further flow of gas through the high-pressure outlet. By imposing on the outside of the diaphragm a spring compressed with an adjusting screw, the pressure required to close the seat is under accurate control, if the regulator is working properly.

The seat must necessarily be of soft material—not to soft to flow under the action of the high-pressure gas, and yet not so hard but that the nipple can find itself a seat surface. Metallic seats, even such as babbitt, are out of the question. Soft rubber will scarcely hold back 2000 pounds gas pressure. Ivory has a distinct grain that permits the gas to leak through. Ivory nut, a natural growth closely approximating ivory in constituent of grain and hardness, is eliminated for certain evident reasons. Casenite, a product of milk, approaches an ideal, when it is properly made, but its lack of uniformity eliminates it. Bakelite is suggested, but Bakelite fails through brittleness at low temperatures. The field of selection inevitably narrows down to hard rubber.

Hard rubber was our choice for a regulator seat when Davis and Bournonville brought the first welding apparatus into this country, and hard rubber is used today, but it had a pretty shady reputation in the interim. Just as oxygen high pressure gauges were destroyed by the insatiable fury of oxygen, so were oxygen regulators returned with evidences of severe combustion that for a long time were inscrutable. True, the proportion of regulators so affected was an infinitesimal proportion of those in use, yet the future of the process depended upon absolute safety, and if one regulator of representative design and construction proved unsafe, the law of probability and chance would have to be considered as inoperative, and the probability of even one regulator being affected entirely eliminated. Since the new principle was incorporated in our regulators four years ago, not one case, authentic or otherwise, has ever been reported of combustion having its inception in the interior of the regulator.

I have explained how the heat of compression in the Bourdon spring of a high pressure oxygen gage created a rise in temperature sufficient to ignite any carbonaceous material present. It interested us to determine whether such a rise in temperature might be effected at the regulator seat, which is distinctly combustible, and is actually the end of an orifice having its start at the tank valve. We inserted a thermo-couple through the regulator seat, the end of the couple extending well into the region of initial compression, and even with a base metal couple with considerable lag we noted a temperature of 375 deg. Fahr. when the oxygen valve was suddenly and completely opened in a short interval of time. If 375 deg. Fahr. was recorded with a couple of considerable lag the temperature would actually be at least double that recorded. Assuming that hard rubber is ignited in an atmosphere of oxygen under high pressure at a temperature approximating 700 deg. Fahr., it is evident that with a particularly bad tank valve and a badly shredded seat surface some seats are bound to be ignited. Once the seat was consumed, the combustion in itself in most cases ceased, but the destruction of the seat removed the check upon the flow of high pressure gas into the low pressure chamber, and of

course the regulator was ruptured. It is true that the rubber hose attached to each regulator, which serves to convey the reduced pressure gas to the torch, would act as a safety valve under ordinary circumstances, but the rise in pressure in this case would be so sudden as considerably to overwhelm the ability of the opening thus afforded to relieve the pressure.

If the difficulty is due to the heat of compression being generated right at the seat, how better could it be overcome than to design a regulator wherein the initial compression took place in a zone far removed from the seat? This is what was done. Instead of designing the high pressure orifice in practically a straight line from the tank valve to the seat, the continuity of this orifice was broken into by a multiplicity of right angle and reverse bends, further assisted by the interposition of a screen of special design that in itself would completely break up the impact of the gas stream and bring the zone of initial compression far removed from the seat. A record of the temperature at the seat in such a regulator recorded no rise above atmospheric, and the trouble apparently is entirely eliminated.

REGULATOR SCREENS

Every regulator must have a screen to prevent sediment from being carried through by the high pressure gas, and deposited upon the seat. The early types of screens, and in fact some in use today, incorporated a mass of absorbent cotton or other fabric, together with a fine mesh metallic screen. Needless to say that best practice condemns the use of the cotton or other combustible material.

The bursting of the rubber hose is not depended upon, in the best designs of regulators today, to act as a safety valve, but actual safety valve fittings of the bursting disc type are provided on each regulator, designed to operate at a pressure slightly above the maximum required to be served by the regulator under operating conditions. Note that if the regulator seat is abused or otherwise harmed, the service pressure will "creep," as it is called, or rise above the adjusted pressure, particularly when the gas is shut off passing through the torch. In this case, the safety valve will relieve the pressure before it could reach disruptive proportion. I might observe, in passing, that a special technical committee has been appointed by the International Acetylene Association to investigate the safety aspects of regulators.

HOSE

The strength of hose permitted in the process is under careful supervision by responsible insurance bodies and other controlling bureaus. The regulator connections of the oxygen and acetylene hose differ, to prevent the indiscriminate change of hose from one gas atmosphere to the other. The torch connections, as well, differ for the same reason. Operators have been known, however, to

change this connection, or to provide adapters, in order, as they believed, to avoid the annoyance of stocking two sets and grades of hose!

Barring conflagration of the hose from extraneous causes, there is but one difficulty that I shall discuss here that has its inception in the hose. A very few authentic cases are recorded, a number of which I have been able to reproduce in my laboratory, indicating that where an operator was using a cutting torch, necessarily employing an oxygen service pressure, e. g., of 100 lb. per sq. in., the oxygen hose suddenly and without extraneous influences burst in one or more places and the hose ignited. In view of the fact that oxygen is not combustible, precluding the possibility of the conflagration being transmitted from an open flame in the vicinity, the combustion must evidently have originated within the hose. We are now working on a principle that promises results very shortly, and I must ask your indulgence in allowing me to present the phenomenon here for record without divulging its exact nature until our experiments are nearer completion. Incidentally, let me record the observation that heretofore this particular phenomenon was the single instance where we were in ignorance of the cause, and where we could provide no corrective measures.

TORCHES AND TIPS

Two basic types of torches are in use in this country, the injector and the positive pressure types. There are innumerable counter-developments of each type, and some of their inventors claim that their apparatus warrants an individual category. Accordingly, we shall concede for this discussion a subdivision of the positive pressure type into balanced and unbalanced pressure. It is a fact, nevertheless, that no torch has yet made its appearance on the market that is actually a balanced pressure torch. The attempts so far to develop such a torch have introduced certain hazards that are not generally known to exist. A true balanced pressure torch would be ideal, both for metallurgical reasons and as a positive assurance of absolute safety insofar as a torch can influence it, and the designers working on this type of torch are to be encouraged. They should accept the fact, however, that they have not realized this design yet. The basic principle of a welding torch is simply a device to receive the two gases, acetylene and oxygen, heretofore maintained in separate conduits, and to mix them suitably in more or less accurately proportioned amounts, to produce a welding flame. The means to this end may vary considerably.

The simplest construction, obviously, is that represented where the torch proper comprises two brass tubes, firmly sealed, at their rear end, into a fitting to which are also attached two control valves, connecting in turn to the hose conduits conveying the gases from the regulators. A handle is provided for convenience in manipulat-

ing the torch. The handle is properly vented to prevent an accumulation of mixed gases that may possibly result from a leakage through faulty tubes or otherwise. The tubes are connected at their fore end to the torch head. The latter is provided with a suitable recessed chamber to receive the tip, held in place by a screwed bushing. The tip must be interchangeable in order to provide for various heating capacities. Each tip in this type of torch is, in effect, a mixing chamber, wherein the gases are more or less thoroughly premixed before being emitted from the tip. The oxygen enters a metering port at the extreme rear of the tip, and the acetylene through radial orifices, and the mixed gases are conveyed through a common orifice at the outlet of which a flame is maintained.

By varying the size of the various metering ports in respect to the size of the outlet orifice, the pressure of gases required to be served by the regulators may and should be accurately controlled. In the positive pressure type of torch, the metering ports are relatively small, so that a positive and measurable pressure is required to force the two gases through their respective ports. The torch I have just described constitutes the general type, which I will refer to as unbalanced pressure. The acetylene pressure, for convenience, is so controlled that it equals in pounds per square inch the arbitrary size of the tip. The oxygen pressure is just double that of the acetylene. A No. 6 tip then requires an acetylene pressure of 6 lb. per sq. in. and oxygen pressure of 12 lb. per sq. in. In the balanced pressure type, on the other hand, an attempt is made to design the sizes of the metering ports so that equal pressures are required on the two gases.

In the injector type the acetylene is conveyed through conduits and ports of large capacity, under a nominal pressure, e. g., of 8 in. of water, sufficient to maintain a flow of gas through the pipe system. The tip is in reality an injector or respirator mechanism. A relatively high pressure forces the oxygen at a high velocity through a small injector orifice, drawing into the stream the proper portion of acetylene. To the best of my knowledge the interest in this type of torch in this country is limited to but one large manufacturer.

WELDING CONE MUST BE NEUTRAL

For metallurgical reasons, the reaction in the oxy-acetylene flame must be such that the atmosphere in the primary reaction, or so-called welding cone, will be neutral. Theoretically, one volume of acetylene reacting with one volume of oxygen produces the desired characteristics. The velocity or propagation of a flame through such a mixture is terrific. Under certain conditions, I have found the speed to approximate 700 meters a second, truly an explosive reaction. The first consideration, then, in designing a torch is to provide an outlet speed of the gas mixture that will

counteract the velocity of propagation of flame. However, the innumerable secondary factors must be considered.

FLASHBACKS

A relatively slight disturbance of the equilibrium will destroy it and cause a reaction in the opposite direction. For example, while the velocity of flame may be properly considered when the mixing chamber is cold, overheating of the tip would when the mixing chamber is in operation increase the rate of combustion, and cause a flashback. Likewise any other force tending to reduce the flow of gas would cause a flashback. On the other hand, any factor tending to reduce the rate of combustion, such as might impure gases, or tending to increase the rate of egress of the gases, would cause the flame to blow away from the tip.

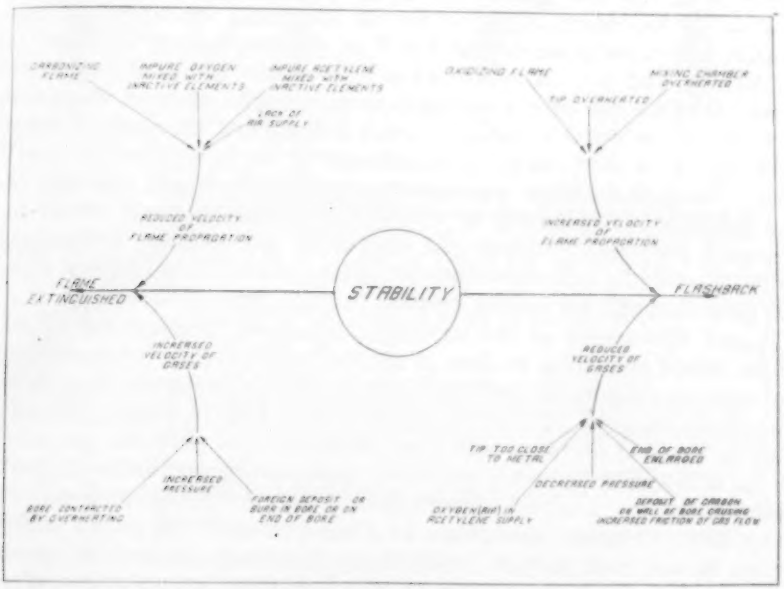

CARBONIZING FLAME
IMPURE OXYGEN MIXED WITH INACTIVE ELEMENTS
IMPURE ACETYLENE MIXED WITH INACTIVE ELEMENTS
LACK OF AIR SUPPLY
OXIDIZING FLAME
MIXING CHAMBER OVERHEATED
TIP OVERHEATED
REDUCED VELOCITY OF FLAME PROPAGATION
INCREASED VELOCITY OF FLAME PROPAGATION
FLAME EXTINGUISHED
STABILITY
FLASHBACK
INCREASED VELOCITY OF GASES
REDUCED VELOCITY OF GASES
INCREASED PRESSURE
TIP TOO CLOSE TO METAL
END OF BORE ENLARGED
DECREASED PRESSURE
BORE CONTRACTED BY OVERHEATING
FOREIGN DEPOSIT OR BURR IN BORE OR ON END OF BORE
OXYGEN(AIR) IN ACETYLENE SUPPLY
DEPOSIT OF CARBON OR WELL OF BORE CAUSING INCREASED FRICTION OF GAS FLOW

Fig. 2. Factors affecting stability of oxy-acetylene flame.

When a flashback occurs, the operator is obliged to shut off both gases at the torch and readjust his flame. Barring a momentary inconvenience, this should give no concern, but a flashback may be the inception of a more serious development. It must be considered that the mixing chamber is in the body of the tip, so that were a flashback to occur, and at the next moment the outlet of the tip be plugged, as by an adhering deposit of molten metal, the unequal pressure of the two gases would tend to equalize themselves by a passage of the gas of higher pressure into the conduits of the gas of lower pressure, the regulator of low pressure, through the very nature of its design, closing and creating thereby a closed circuit. Furthermore, where the two gases are in contact, the combustion

continues, and this zone of combustion is carried back by the flow of gases. In the unbalanced pressure torch, the combustion is evidently carried into the acetylene hose.

We conducted some interesting experiments to study the propagation of a flashback. By interposing glass tubes in the conduits immediately behind the torch we were able to see the combustion as it was driven back into the hose. A characteristic observed was that the combustion was relatively quiet, and incomplete, depositing considerable carbon. It took place, generally, in a zone not over ¼ in. in width, and completely across the cross-section of the gas stream. The combustion was held within the glass tube for an appreciable moment, and it continued to react in a quiet manner, without, as might be expected, creating a vortex, and subsequently a mixture of the two gases throughout a large volume. In other words, the flashback might be driven back into the acetylene hose, caused to return towards the tip, held at one place in the hose for an instant, and yet not create an explosive mixture in the acetylene hose. While some of our contemporaries might contend otherwise, in no instance were we able to drive a flashback through an acetylene regulator that could be considered to be in serviceable condition. Even though the regulator seat leaked a slight amount, the quenching action effected by the minute orifice formed would not permit a passage of flame. Le Chatelier, the eminent French scientist, proved by his experiments that an oxy-acetylene flame could not pass through an orifice smaller than ½ mm. in diameter.

A full discussion of the various phenomena presented in flashbacks would require a review of the various types of torches which for obvious reasons is unsuitable for a paper presented before the American Society of Safety Engineers. The balanced pressure type is touched on here only for the purpose of pointing out some of the difficulties encountered when undertaking to eliminate flashbacks entirely. Instead of introducing the acetylene streams into the mixing chamber in a plane at right angles to the outlet orifice, which would tend toward complete pre-mixture of the two gases, they are led in, in the balanced pressure type, at an angle of 45 deg. inclined towards the outlet. By varying the sizes of the various chambers, the acetylene pressure could be made approximately equal to the oxygen pressure, and the velocities of the various gas streams nearly identical. With the acetylene introduced through a multiplicity of streams to the core of oxygen, both gases merging at the same approximate pressure and velocity, the identities of the streams are maintained, and complete premixture prevented. That this condition exists is readily proved by looking endwise upon the flame produced by a tip of such construction. It can be seen that the flame has a distinct lobe corresponding to each of the points of ingress of the acetylene into the mixing chamber, so that the stratified relationship of the two gases persists throughout their passage from the mixing chamber. It is evident that a flame can not

propagate through even an acetylene and oxygen conglomerate, if the two gases are unmixed, excepting at their contacting surfaces where diffusion has taken place. Even a slight velocity of exit would overcome this.

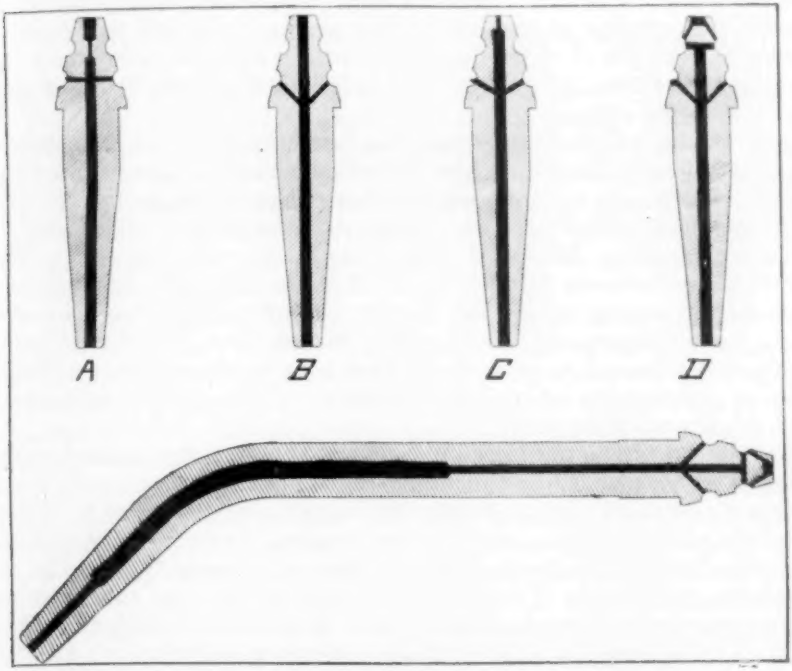


Fig. 3. Sections of Davis Bournonville tips, illustrating development of non-flash back type.

ACETYLENE PRESSURE ABOVE OXYGEN

While this type of torch is called a balanced pressure torch, actually the acetylene pressure is substantially higher than the oxygen pressure. Entering the mixing chamber as they do at an inclined angle, the acetylene streams are bound to exercise a certain amount of aspirating action upon the oxygen stream. As a matter of fact, the excess acetylene pressure is emphasized by the manufacturers as explanatory of the action of this type of construction to eliminate flashbacks. It is claimed that when the end of the tip outlet is slightly obstructed, the excess acetylene pressure will disarrange the ratio of mixture of the two gases entering the mixing chamber and the mixture will be richer in acetylene. It is true that the velocity of propagation of a flame through such a mixture is considerably reduced and in a measure this contributes to discourage a flashback. While such tips are acclaimed as immune from flashback, actually the application of their principle of construction is only effective below a certain size of outlet orifice. This limitation

has been definitely determined in our own experiments and exemplified in the apparatus as exploited as existing in a mixing chamber orifice of slightly less than 1/8 in. cross-section. The maximum size of the flame orifice used in the process is substantially equal to a No. 20 drill or .161 in. cross-sectional diameter. Evidently, it is within the realms of probability that such a torch will flashback in service. As the acetylene pressure in this case is higher than the oxygen pressure, the flashback, if the tip end is closed, will propagate into the oxygen hose.

As the flashback accompanies the contact zone of the gas streams as they equalize their pressure, it is evident that at the moment the flow is reversed, by removing the obstruction at the end of the tip, the combustion hesitates momentarily Evidently, at this point, it heats the rubber hose even to the temperature of ignition. In the unbalanced pressure torch, this heated zone is immediately quenched by an atmosphere of acetylene, and no ill effects result—the acetylene as you know will not support combustion. In the so-called balanced pressure torches the heated zone is immediately covered by an atmosphere of oxygen, generally resulting in a combustion of the hose at this point.

We were interested in the non-flashback characteristics of a tip, however, because it has undeniable merit; but the oxygen pressures must be retained. Accordingly this simple expedient was adopted: the oxygen metering port is as far removed from the mixing zone as possible so that its pressure is dissipated and its velocity reduced. Accordingly it meets the acetylene streams at substantially the same pressure and velocity. This is positively assured by bypassing the oxygen after it leaves the metering port through a multiplicity of ports where its pressure is thoroughly relieved, and its velocity reduced to the desired rate.

In another type of non-flashback construction the mixing chamber is the same, but between the mixing chamber and the outlet is an expansion chamber. When a flashback begins, it travels back through the flame orifice until it reaches the expansion chamber. Here the mixed gases are traveling so slowly that the flashback passes through this chamber with explosive violence. It cannot pass through the unmixed gases in the rear chamber, so it consumes itself, and the torch is reignited practically automatically; as the outlet orifice is independent of the mixing chamber, it can be made as large as the service requires. The only disadvantage with this type is that the explosion of the gases in the mixing chamber spatters the molten metal of the weld in a disagreeable manner.

I have only begun to consider the many phases of the process where safety has an important bearing. So far as the company I represent is concerned, the apparatus is practically fool-proof and is as ultimately safe as any apparatus of such potential power can be. We have been able to meet and correct practically every hazard that has heretofore been associated with it.

ON THE APPLICATION OF ELECTRIC ARC WELDING TO TWO VESSELS *

By M. HARMIISHI

Abstract of Paper Read Before the Japanese Society of Shipbuilders

IN Japan, some years ago, Dr. K. Ito, of the Mitsubishi Dockyard and Engine Works, Nagasaki of the Mitsubishi Shipbuilding Co., Ltd., introduced and recommended the adoption of the Kjelberg's arc welding system to his works after he had seen it in operation in Sweden. Since then it has been used to some extent to repair cracks and blow-holes in iron and steel castings at the Nagasaki Works and at the Hikoshima Dockyard of the same company of which I am manager.

I learned that in England, arc welding was being adopted and so much used that Lloyd's Register of Shipping had been under the necessity of issuing tentative rules for its use in the building of ships and was therefore led to give the subject further study, and resolved to try it on ship construction should the chance arise, even although our Government Surveyors still declined to use it either on ship construction or even on ship repairing. For trial purposes, I considered it would be advisable to adopt it on a small craft, such as a barge or lighter, with which our surveyors would not have occasion to interfere. On looking out for such a job, I obtained an order at the end of last year to convert a steam trawler, the "Dairyo Maru," into an oil lighter, capable of carrying about 300 tons deadweight, and I secured the owner's sanction to do this job with electric arc welding as far as it could be suitably managed. The job was completed quite successfully by the arc welding process to her owner's entire satisfaction.

The next attempt was made on a steel self-floating caisson for the new dry dock of our Hikoshima Dockyard, known as our No. 2 Dock, 460 feet long. The caisson was designed by us, and constructed with arc welding very satisfactorily in the Hikoshima Dockyard, and is working very well without giving any trouble at all.

Details of these applications are given herewith:

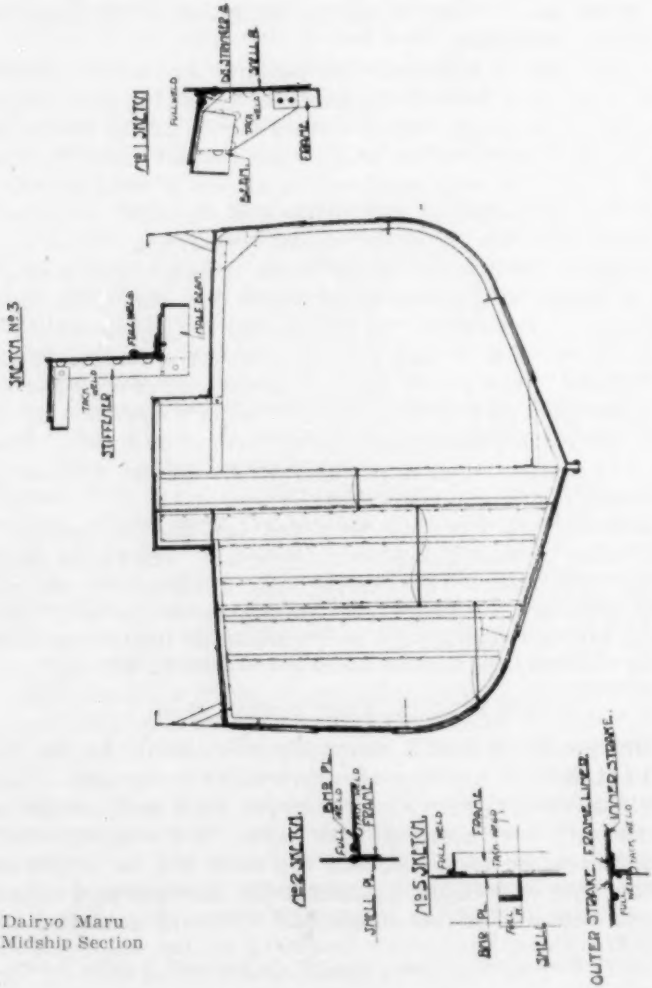
WELDING ON THE "DAIRYO MARU"

The Dairyo Maru was a steam trawler, 95 ft. by 26 ft. beam and by 12 ft. 6 in. in depth, and calculated to be capable of carrying 297 tons deadweight, provided her upper deck were raised up into a fair line with her raised quarter deck. Her original wood deck planking had to be removed, and the deck had to be plated over. The middle line watertight bulkhead, the bunkers and casings and the engine seat and boiler stools had all to be removed, and the

*To be read before the New York Section of the American Welding Society.

collision bulkhead and the after peak bulkhead had to remain as they were before. Then the vessel had to be fitted with six new oiltight bulkheads, so as to form two cofferdams and five oil compartments, and with an expansion trunk extending the full length of the oil compartment, as shown on the plan attached. All deck houses, casings, funnel, mast, all items of outfit and equipment on the deck, the main machinery and deck machinery, the shafting, the piping, all items of engine equipment, which were unnecessary in the vessel as an oil lighter, had also to be removed.

Having rearranged the vessel as an oil lighter, I decided to proceed with electric arc welding as far as possible, wherever the reconstruction of the hull in way of oil compartments and cofferdams



Dairyo Maru
Midship Section

permitted, except some parts in the compartments and most parts beyond the compartments which had to be riveted up, because I had only ten experienced welders and five arc lines, and also the contract time prevented my going further with the welding process.

Some of the details of the reconstruction of the hull and application of the electric arc welding may be explained as follows:

Frames.—All frames were left as they were before, and where the deck was raised the beam brackets were made and fitted as shown on sketch No. 1. Each beam bracket was lapped on to the beam angle and tack welded on the slab; placed in position, bolted to the head of the original frame, faired and riveted with two rivets and afterwards tack welded to the shell.

Where a new bulkhead was arranged, the original reverse frame and floor plate were removed, the beam angle was renewed with an angle of same size as the main frame, and extended down to the head of the original frame. The bulkhead plating was lapped on to the frame, as shown on Sketch No. 2.

In order to make the ordinary frame oiltight, the heel of the frame angle to the shell, and the lap of the bulkhead plate to the vertical flange of frame bar, were full welded on the same side of the frame and tack welded on the other side.

Keelsons and hold stringers.—These were left as they were before, but were cut in way of the new bulkheads, and compensated with bracket plates. These brackets were tack welded to the shell and bulkheads, but riveted to the keelsons and hold stringers (see profiles).

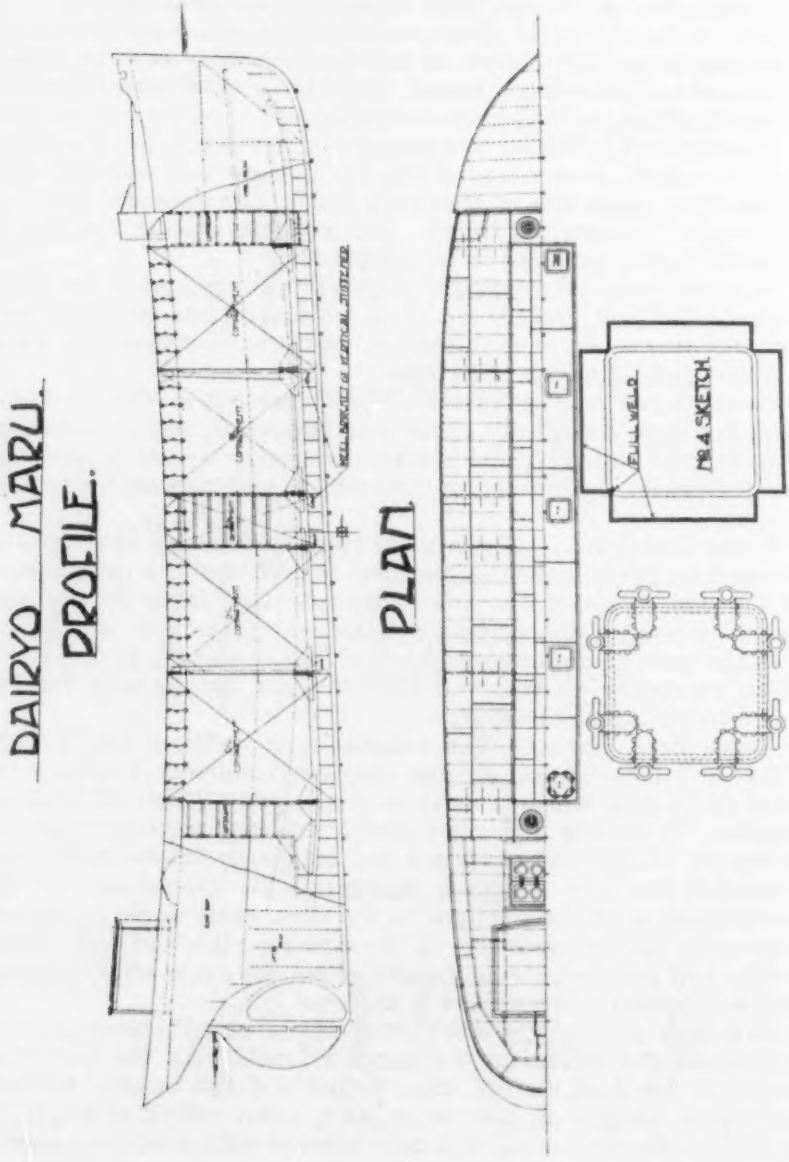
Upper deck beams.—The original upper deck beams were utilized as much as possible, but where these proved short in consequence of the disposition of the new bulkheads (for instance, the half beams in way of the original hatchways) they were lengthened with the same size of angle and joined into one length by full welding on the slab before they were fitted in place, and the beam bracket was fitted as already described.

Upper deck plating.—The original deck stringer plates were utilized, but the holes for the original waterway angles were filled up by plug welding, as these angles were dispensed with altogether. New deck stringer angles in this case were fitted on the underside of the plate between the bulkheads intercostally, and riveted to the shell and deck stringers. To compensate for the discontinuance of the strength of the bars, short angle lug pieces were fitted on the upper side of the stringer plate and full welded to the shell and deck stringer right round the angle after the deck stringer had been full welded to the shell.

New deck plating was laid in way of the oil compartments and cofferdams and riveted to the beams as usual. All the butts and seams of the deck plating were butted and full welded without any straps, because on such small craft, under 100 ft. in length or so, and, moreover, having only been covered with wood deck plank-

ing originally, I did not consider it necessary to increase the longitudinal strength any further, although it might be necessary in the case of a large ship. I also found out that it is far easier to make the deck oiltight without lapped seams in way of the bulkheads, and also to keep it dry.

Expansion trunk.—For the side plating of the trunk, the original



bulwark plates, which had been removed and replaced with the new sheer strake plates where the upper deck was raised, were utilized after such openings as water sports, scupper holes, etc., had been closed up with pieces of plate, and full welded right round; and where required, new plates were fitted. The trunk side was connected to the upper deck with a bar, and the heel and toe of the vertical flange of the bar were full welded. The deck flange was riveted to the upper deck, and its toe light full welded as shown on sketch No. 3. The butts of the trunk side were butted and full welded without straps. As to the trunk side stiffeners, flat bars were used and fitted, tack welded to the trunk side and bolted to the upper deck half beams and trunk top beam as shown on sketch No. 3. The spacing of the stiffeners was the same as the spacing of the frames.

The trunk top plating was riveted to the beams and full welded at the seams and butts without laps or straps and the top corners of the trunk were full welded without corner angles.

The manholes or oil hatchways were formed of angle bars fitted on the trunk top and full welded. Anglesmith work on these hatches was very easily done, as shown on sketch No. 4, by simply cutting the deck flange and bending the vertical flange to the shape at the corners and by butt welding at the end of the angle bar. The hinges to the manhole door and the tightening screws were just fitted on to the door and the manhole angle where convenient, and tack welded, without any holes either in the door or the angle or in the hinges, thus dispensing with all drilling, and the trouble of leaks.

Bulkheads.—Six entirely new oiltight bulkheads were fitted in place as arranged on the profile plan. All the longitudinals were cut at the bulkheads and connected to them with brackets.

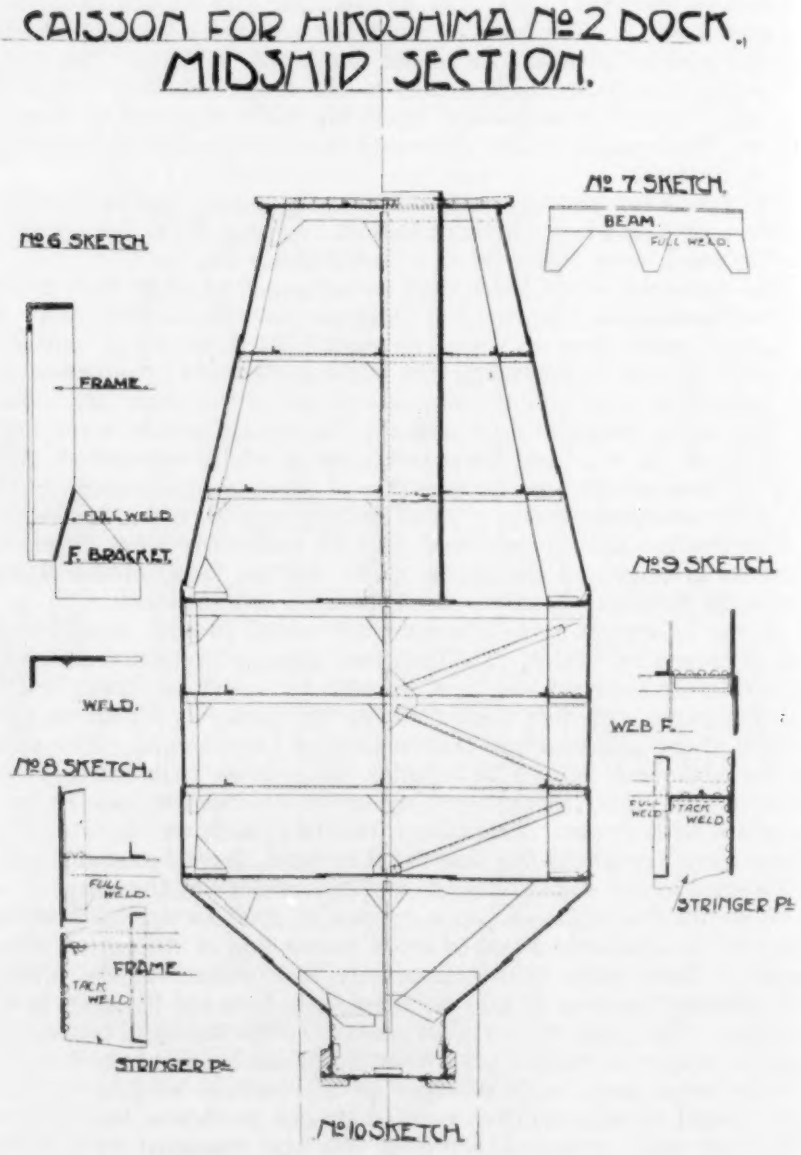
As the bulkheads were comparatively small in size, the plating was arranged vertically. The bulkhead plates were butted and full welded to the required length on the slab (I took them from stock), and the angle stiffeners were fitted on the plate, as shown on the section of the bulkhead and tack welded on the slab also. The size of the stiffeners is a little smaller than those required by the Government Rule (in the riveting system), and the spacing arranged a little closer. After these had been done on the slab, the plates were brought to the ship fitted in place, lapped at seams and full welded at one edge of the lap and tack welded at the other.

To secure the bulkhead plates vertically, four service bolts were provided at a suitable distance apart to one side of the seam. The heads of these bolts were temporarily tack welded to the plate, and extended washers fitted over these bolts fastened the plate laps together. The plates were tightly secured to the bulkhead boundary angle by means of wood shores wedged against the adjacent frame.

I had some fears as to whether or not vertical welding on the seams could be successfully executed by our workmen, but it was done very well. Overhead welding was also managed very well,

but it occupied more time. The watertight testing with a water head of 6 ft. above the trunk top was very successfully carried out; though we found slight leakages at places where overhead welding had been done. They were caulked and stopped at once.

Bulwark and its stays.—New bulwark plates were fitted, lapped to the sheer strake and full welded at seams and butts. As to the



bulwark stay, I used a piece of plate and fastened it directly to the deck and to the bulwark by tack welding with no connecting angles.

ON A STEEL CAISSON

On this undertaking the following parts were arc welded:

Frame to frame bracket; beam to beam bracket, and to a bracket in way of centre stanchion; hold stringer to shell; frames and web frames; deck stringer to shell and frames; seams and butts of upper deck plating; bulkheads and trunks; shell flange of web frame, floor plate to box keel; at bended corner of angle bar worked by anglesmiths, etc.

Frame to frame bracket.—As shown on sketch No. 6, the heel of the frame bar was cut, butted to the frame bracket and full welded on the slab to the shape.

Beam to beam bracket, and a bracket in way of centre stanchion. As shown on sketch No. 7, the brackets were made to the shape, butted and full welded in position on the slab, entirely without laps.

Hold stringer to shell, frames and web frames, as shown on sketch No. 8. The stringer plate was burned off by acetylene gas and cut to the shape of the frame bar where frames pass through; fitted in place and tack welded directly to the shell, without any shell angle between the frames, and tack welded to the frames and to the web frames at ends, but riveted to the beams. By this method, the longitudinal strength might be restored to a certain extent by welding the break in the stringer plate to the frames and web frames, and also by adding a small piece of plate to the outside of the face flange of the web frame and full welding to intercostal stringer plates as shown on sketch No. 9. The stringer face angles were riveted to the stringer.

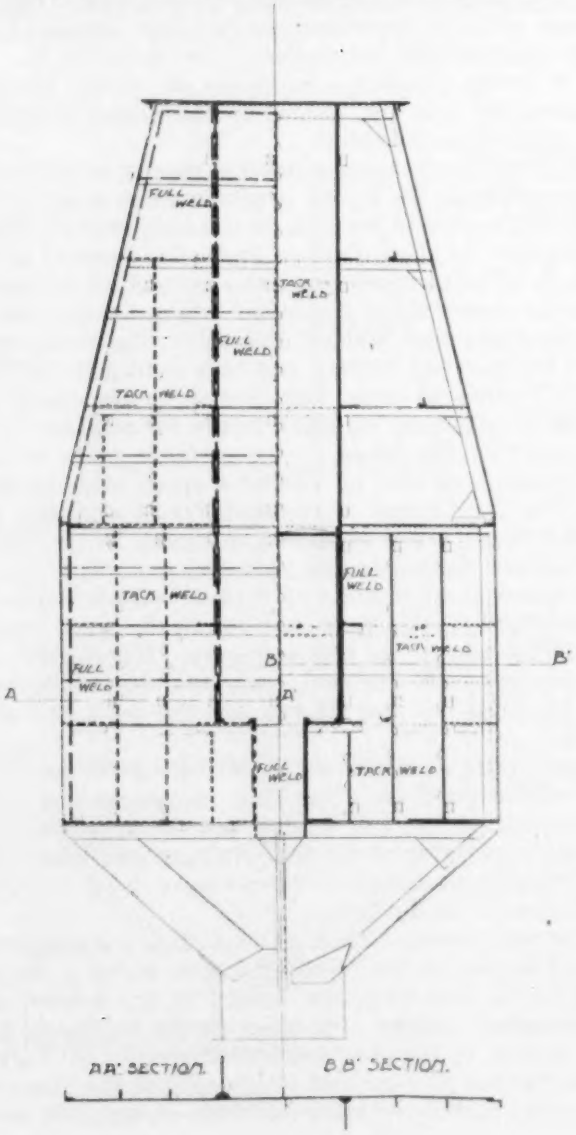
Deck stringers to shell and web frames.—Deck stringers, except where watertight decks were not required, were fastened and welded as in the case of the hold stringers. Where watertight deck plating extended over, the deck stringers were connected to the shell with an angle bar and riveted, and the butts and seams were full welded.

Seams and butts of upper deck plating.—In order to facilitate the laying of the wood deck planking, the seams and butts of the plating were butted and full welded, but the upper deck boundary angles on the upper side of the deck stringer and longitudinal shell connecting angles underneath the stringer were riveted. (See midship section of the Caisson).

Bulkheads and trunks.—The bulkhead plating was arranged horizontally, and lapped on the clincher system and full welded on the upper side of the laps and tack welded on the bottom side. The bulkhead boundary angles connected to the bulkhead and to the shell were riveted to the shell and full welded to the bulkhead just in the same manner as described in the case of the "Dairyo Maru." The trunks were plated vertically and their corners full welded with-

out any corner angles. Flat bars were used as the vertical stiffeners spaced about 24 inches apart. On these short angle lugs were tack welded on the slab before they were fitted in place, to secure them

CAISSON FOR HIROSHIMA No 2 DOCK.
W.T. Bhd & PARTIAL Bhd.



to the bulkhead, and then they were fitted on the bulkhead and tack welded. The trunks had no deck angles except those on the upper deck, which were full welded directly to the deck (see W. T. bulkhead and partial bulkhead plan).

Shell flange of web frame.—The shell plating was arranged on the clincher system, and in order to dispense with tapered liners (because if I could have got some hands and time, I thought I would also weld the seams), it was intended that the shell flange of the web frame should be joggled. However, I had no hydraulic press powerful enough for this work, and no channel bars suitable for the purpose, and so the webs were built up to the shape and had a joggled flat bar fitted as shell flange and just an ordinary plate bar as face flange, full welded to the web plate.

Floor plate to the box keel.—The floor plates were fastened against the short angle lugs which were tack welded to the keel plates before the keel was laid on the blocks and then tack welded to the keel, as shown on sketch No. 10.

At bent corners of angle bars worked by the blacksmith.—These bars, such as upper deck end corner bars, hatch corner bars, etc., were made in short pieces and bent by the anglesmith by cutting one flange and full welding directly, or adding a small piece of plate as the case of bending may require, and then fitting in place. This arrangement greatly simplified the smithwork.

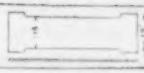
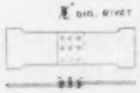
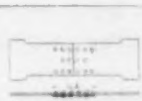
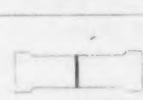
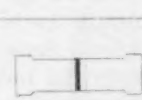
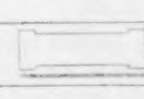
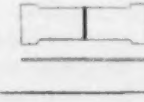
Miscellaneous works.—Compensating doubling plates to maintain the strength, and doubling around manholes, were punched for tack holes only, and after being secured in place these holes were plug welded and full welded right round the doubling without any holes in the plate to which the doublings were fitted. The plates for the floating pipes were bent to the shape and full welded at the butt edges, and then they were placed in position and full welded to the shell and the fore and aft diaphragm plates with no connecting angles at all. Hand rail stanchion sockets, steps, eyeplates, and all similar deck fittings were placed in position as required and tack welded. The fastening bolts for the fender timbers outside of the box keel and around both ends of the caisson were arc welded to the plating with no holes in it. In all cases the widths of welded laps were reduced to the width of single riveted lap joints.

I would call your attention to a table showing tensile and elongation test results of arc welded and riveted joints on mild steel, made by the Nagasaki Shipyard of the Mitsubishi Shipbuilding Co., Ltd., from which you may clearly observe the results. It may be that the alternating bending tests on arc welded joints will show some defects as compared with the original mild steel plate, but I should like to ask you to discover for yourselves if a plate, cold joggled, could stand against the same alternating bending tests any better than an arc welded joint. It may be that foreign matter and defective material can be found in an electrode,

and cause porosity of the weld, but it is very difficult to inspect and avoid them, but can you by looking at any castings find out any internal defects and be assured the casting is perfectly sound, without breaking it?

After all, a very important factor is the experience and skill of the arc welder, but this is also true not only in the matter of the electric arc welding, but in every other trade equally.

TENSILE TEST RESULT FOR ELECTRIC WELDING & RIVETED JOINT
MILD STEEL PLATE

SKETCH OF PIECES	TONS PER SQ IN.	TONS IN % OF ORIGINAL	ELONGATION FOR 2"	%		REMARK
	31.5	100.00	6 4/8" 6 3/16" 6 2/16"	23.8		ORIGINAL
	22.6	71.74	3/8" 3/8" 3/16"	1.4		CAULKING OPENING 87.5 TON
	21.1	66.98	3/8" 1/2" 1/2"	1.9		CAULKING OPENING 64.8 TON SLOPE 1/8 - 8 TON
	24.2	76.82	1 3/16" 1 1/16" 1 1/2"	5.3		CAULKING OPENING 81 TON
	20.7	65.71	1 1/8" 1 1/2" 1 1/8"	4.6		CAULKING OPENING 71.3 TON
	21.7	68.88	1 1/16" 1 1/16" 1 1/16"	6.3		CAULKING OPENING 121.1 TON
	21.7	68.88	1 3/16" 1 1/16" 1 1/16"	6.3		CAULKING OPENING 97.2 TON
	31.5	100.00	2 1/16" 2 1/16" 2 1/8"	8.1		
	31.3	99.36	2 1/2" 2 3/16" 2 3/16"	9.5		
	31.5	100.00	2 3/8" 2 1/16" 2 3/16"	10.0		
	31.8	100.95	3 3/16" 3 1/2" 3 3/16"	13.0		
	31.2	100.00	4 1/16" 4 1/16" 4 3/16"	16.4		ORIGINAL
	27.3	87.50	1 3/16" 1 1/16" 1 3/8"	5.3		
	28.4	91.02	1 1/2" 1 1/2" 1 1/2"	5.6		

The principal advantages and disadvantages of the electric arc welding process may be roughly summarized as follows:

ADVANTAGES

1. Minimizing the marking labor on material and the saving of time.

2. Minimizing or dispensing with punching or drilling labor, tool damages, and saving of time and tool costs.

3. Minimizing the costs of transportation of materials and saving of time.

4. Minimizing the number of service bolts and washers and the labor of securing; and saving the loss of bolts and washers and also of time.

5. Minimizing the number of rivets, the labor of riveting, the consumption of coal, the damage to riveting tools and rivet heating forges.

6. Minimizing the drilling labor for deck fittings and the saving of time.

7. Minimizing the width of the laps and butt straps of the plating, the numbers of connecting angle bars and the rivet heads, or dispensing with them altogether, and the saving of the materials.

8. Minimizing the caulking labor and time.

9. Minimizing the number of punching machines and drilling machines in the yard, and also the air compressing plant if pneumatic riveting hammers are being used.

10. Minimizing the general labor and oils, etc., in connection therewith.

DISADVANTAGES

1. The increased length of plate edge planing and beveling, and the labor and time in connection therewith.

2. Increased difficulties in securing the material in place and the time occupied in doing so, especially on double curved plating. (It is expected that these items will be reduced by skillful design and increased experience on the part of the men.)

3. Increased electric installation and power.

4. Increased labor to fair the deformations or bucklings of plates caused by the welding process and the time occupied in connection therewith.

5. Difficulties of inspection.

6. Difficulties in obtaining well-experienced welders at present.

7. Slowness of the welding speed as compared with the present speed of riveting, and specially on overhead work.

By studying and investigating these comparisons, it will be found that, after all, a saving may be effected on labor, time and costs.

SOME PROBLEMS OF THE JOB WELDING SHOP*

By S. W. Miller

BY a job shop is meant one which takes in any kind of work which is brought to it. The work may be large or small, easy or difficult, and there may be much of one kind or there may be no two jobs alike. The job welding shop comes under this specification but has an additional difference. The work is almost entirely repair work. In repair work of any nature, the objects are to have the repaired part strong enough to stand the service required of it, and to do it at a price as low as possible, consistent with good workmanship and a fair profit. There are many difficulties in accomplishing this result in a job welding shop.

In considering these difficulties, we will confine our attention to repair work because in production work the difficulties can be overcome in the course of a short time, and after this has been done, the rest of the work is comparatively easy. The difficulties in a job welding shop may be classified as follows:

First, the work itself. Second, the varied natures of metals that are of the same general type. Third, financial problems. Fourth, guarantees on the work.

WORK

The first head may be sub-divided into the following:

"A"—Preparation.

"B"—Welding.

"C"—Finishing.

The preparation of the work involves the making of the V, the method of lining up the work, and the arranging for and taking care of the expansion and contraction.

The welding covers the decision as to whether gas or electric welding be employed, and upon this decision somewhat depends the preparation. The method of pre-heating really should be considered in connection with the welding, although it is important enough in some cases to be considered separately.

The method of finishing the work, if finishing be necessary, as do all the other operations, depends on the facilities on hand. It is difficult to lay down general rules for any of these matters and it is probably best to consider what has been done in individual cases.

VARIED NATURE OF METALS OF SAME GENERAL TYPE

Under the second heading, it should be remembered that in a production job the material used can be specified so that uniformity can be obtained, which enables the welder to use the same methods and practices at all times. In repair work, however, not only are

*Paper read before January, 1922, meeting, Northern New York Section, American Welding Society.

the materials, for instance, cast iron, not uniform, but in many cases it is impossible to determine before the welding is started how the material is going to act during the welding process, and sometimes changes in methods have to be made in order to overcome difficulties of this nature that could not be anticipated.

The only thing that will guide a welder under such adverse conditions is experience, and to use this experience the welder's memory must be good and his observation keen.

The job shop is called on to handle all metals and it is seldom that one finds a welder who is able to do all of them well and still rarer to find one who is capable of doing all-around welding with both gas torch and electric arc.

It is sometimes difficult to distinguish between cast iron, malleable iron and cast steel. It is frequently impossible to distinguish between the various brass and bronze alloys and many failures have occurred because of these troubles. Similar difficulties exist with other metals, so that the job shop, to be successful, must have a wider knowledge of metals and their characteristics than any other kind of a shop.

FINANCIAL PROBLEMS

Third, the majority of job shops do not have any real knowledge of their costs, and it is frequently the case that where there are a number of competitors in the same city, prices will be cut and recut until the work is being done at an actual loss by everybody. Such a condition is bad for the welding industry, but it will not be overcome until such shops see the importance of knowing what the work costs them. To do this is not so difficult, but does require a proper system of bookkeeping and a simple accounting method. Any good accountant will, at small expense, install a suitable system, but he must bear in mind the character of the average job shop, which is not competent to understand or to use complicated methods, and which do not have time to spend in using elaborate blanks, slips, tickets, etc.

The nature of the system installed depends on the work being done, and it is impossible to give any specific data. It will be enough to say that all the time put on the work must be accounted for and that an approximate idea of the gases or current consumed must be known. Allowance must be made in the gas cost for gas that is not used from the tanks, especially in the case of acetylene, where quite a little of it cannot be used especially in cold weather.

On the other hand, too much time must not be occupied in collecting accounting data, because if this be done it may cost more to get the information than is saved by getting it.

The items that are most frequently overlooked are those that are usually called overhead expenses, such as insurance, taxes, repairs of apparatus and advertising. I do not mean that these expenses are not paid, but that they are not included in the charges

made for the work in an intelligent way. Of course if the real cost of the work being done is not known, it is impossible to say what the charges should be, and charges must include a profit over all expenses, or else the business will fail.

In connection with the financial end of the business, the treatment of the customer is of vital importance. A satisfied customer is the biggest asset of the business. Of course a customer cannot be satisfied unless the work is done properly, and at a reasonable price. The most essential thing, however, is to do the work properly, even if in some cases it has to be done at a loss, and as a matter of policy, I believe it is wrong to do cheap work, that is, work which is deliberately so done, even with the understanding that first-class work is not needed. Of course, if the best work is not really necessary it is wrong to spend more money on it, but it is a frequent occurrence to have customers ask for a cheap job in order, for instance, that they may dispose of an automobile, their idea being as soon as it is off their hands, they are not responsible any further. But a moment's thought should convince us that such a policy is unfavorable to the welding shop, for if the part fails, no excuse on the part of the welder will remove from the mind of the owner of the car the idea that he has been injured and that welding is of no value. It is far better policy to refuse to do work of this character. Further, it is much easier to explain to the customer that good work has been done and to collect the money for it, than it is to explain an unsatisfactory job.

Inasmuch as many customers are entirely unfamiliar with welding, it is frequently necessary to go into detail as to the reasons for doing certain things. The customers frequently cannot understand why an intricate casting has to be pre-heated and slowly cooled, but if the matter is explained to him in a careful and thorough manner, he is usually willing to accept the explanation. If he is not willing and can not be made to see that a certain procedure is necessary, it is far better to let the work go than to do it in a way which the welder knows will be unsatisfactory. On the other hand, if the welder is so unfortunate as to do a piece of work badly, the best policy is to honestly admit it and explain why. There are so many jobs that come to the welding shop that have never been done before that it is no wonder that failures sometimes occur, and honesty in this, as in all other cases, is the best policy. I speak of these things in some detail because they are many times overlooked or not understood or appreciated.

GUARANTEES

A welding shop is frequently asked if it guarantees its work, and such shops frequently advertise that they guarantee all jobs. A general statement to the effect that all work is guaranteed in

reality means nothing and there should be some specific form of guarantee covering all usual cases.

It is also well to know that, in all probability, a general statement as to any guarantee is not legally effective unless it is specifically called to the attention of the customer before the work is undertaken, and if it is not intended to guarantee the work, the customer should be advised of this at the time the work is taken in, and in important cases the further precaution of notifying him in writing should be taken.

Again, a guarantee is of no greater value than the ability and willingness of the welding shop to fulfill it. It may be that the financial strength of the welding shop is not sufficient to properly guarantee some important work. In such a case the safe course to pursue is to have the work done by some larger shop in order to avoid financial loss.

Whatever is done in the way of guarantees should be done as a matter of principle, and the policy should be followed strictly and altered only as experience indicates that changes may be safely made.

PRECAUTIONS

As in all other work, welding has its tragical and humorous sides. The tragical may be well represented by the accidents that have occurred either through lack of knowledge or pure carelessness, as when tanks that have contained oil, gasoline or other explosives have been worked on with a cutting or welding torch. It is equally dangerous to work on them with the electric arc. Explosions have occurred even after a tank has been washed out with water, or, steamed out, so that the only safe way is to keep the tank as full of water as possible while the work is being done. It should first be filled entirely, care being taken to see that all pockets are filled. The water can then be let out just enough so that the welding can be done.

It is a good rule to keep visitors out of the welding shop unless they are accompanied by someone who can take care of them. It is also a good rule to keep beyond possible range of the torch flame. Some welders have a habit, which is a bad one, of turning the torch flame toward their shoulder in order to look at the work, and I know of one case where a man who was standing back of the welder had the torch flame turned in his face.

The dangers of looking at the electric arc are well known to you, and in all cases precautions should be taken so that even side flashes from the arc may not get to anyones' eyes. It may sound incredible, but there is one instance on record where a welder endeavored to stop a leak on an acetylene generator by welding, with, of course, fatal results. In my own experience I had a welder, whom I employed temporarily, build a small charcoal fire on top of a Prest-o-lite tank during cold weather, in order, as he said, to

thaw out the acetylene regulator. Fortunately, in this case the fusible plugs operated, and while the flame shot twenty feet in the air, no damage was done.

There are many humorous questions asked by customers; that is, they are humorous to us. One of these questions is quite frequent, that is, whether cast iron can be welded. Courtesy and tact demand that we should not smile under such conditions, but that a careful explanation of the principles of fusion welding be given, so that the customer may understand that all metals may be joined together by these processes. Then his idea of welding will be broadened and his confidence in it increased. It is even sometimes necessary to demonstrate to the customer that metals can actually be melted together. As a matter of fact, we can all be asked questions in connection with welding which we are unable to answer, and people that live in glass houses should be careful about throwing stones.

ITEMS OF INTEREST

AIR-COOLED SUIT DESIGNED TO PROTECT WELDERS

OUR attention has been called to the fact that a new type of air-cooled suit has been recently invented and is designed to protect the oxy-acetylene welder from the heat he is exposed to in doing heavy welding in confined places. The inventor claims that the workman equipped with this suit is protected from the heat by the circulation of the air around his body. The air passes through the mesh of the fabric of which the suit is made and is supplied by a pan through a flexible tube fastened to the suit.

In very hot work the helmet is used to protect the welder's head from the heat and also to supply fresh, cool air for breathing. The suit is also supposed to be a protection against poisonous gases and can be worn for hours at a time without discomfort.

CURRENT WELDING LITERATURE

TO OBTAIN COPIES OF PAPERS—The Engineering Societies Library is prepared to supply copies, translations, or abstracts of any papers in the Library at the following rates:

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Angular Welds, Marcel Piette, Revue de La Soudure, Autogene, Paris, November, 1921. An illustrated, semi-technical article on the strength of angular welds made on sheets and tubes. Greater strength can be secured by decreasing the sharpness of the curve at the angle.

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NEW BOOKS

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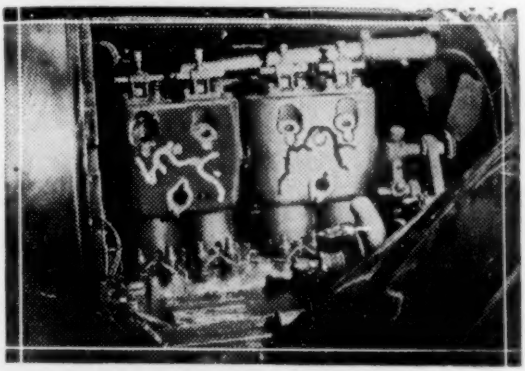

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